ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 63. No. 11. 220 Broadway, New York, March 17, 1910.

TABLE OF CONTENTS.

LEADING ARTICLES:	Page.
Inside-Glazed Greenhouses in the Berlin Botanical Gardens (illustrated)	299
Dangers Arising from the Transportation and Storage of Ferro-Silicon	300
The Nisqually Hydro-Electric Plant of the City of Tacoma, Wash. (illustrated)	302
Twenty Years' Experience with an Employees' Advisory Board; E. Blum	303
Effect of Water Diversion for Power Purposes on Niagara Falls	306
Specifications for Sheet Asphalt Pavement	307
Specifications for Concrete Sidewalks, Curbs and Street Pavements	308
Specification for Bituminous Concrete Paving	309
Shrinkage and Forced Fits and the Stresses They Produce (illustrated); A. Lewis Jenkins, Jun. Am. Soc. M. E.	310
Annual Meeting of the Illinois Water Supply Association	312
Reinforcing Compression Members of Concrete in a Plane Transverse to the Line of Thrust; Robert A. Cummings, M. Am. Soc. C. E.	313
A Boat-Torpedo of Enormous Destructive Power, Carrying Its Own Gasoline Engine and Crew	314
Laying Concrete under Water on the Detroit River Tunnel (illustrated); Olaf Hoff, M. Am. Soc. C. E.	318
Destruction of a Reinforced-Concrete Arch Highway Bridge in Indiana (illustrated)	321
Partial Failure of a Concrete Dam at Austin, Pa. (illustrated)	323

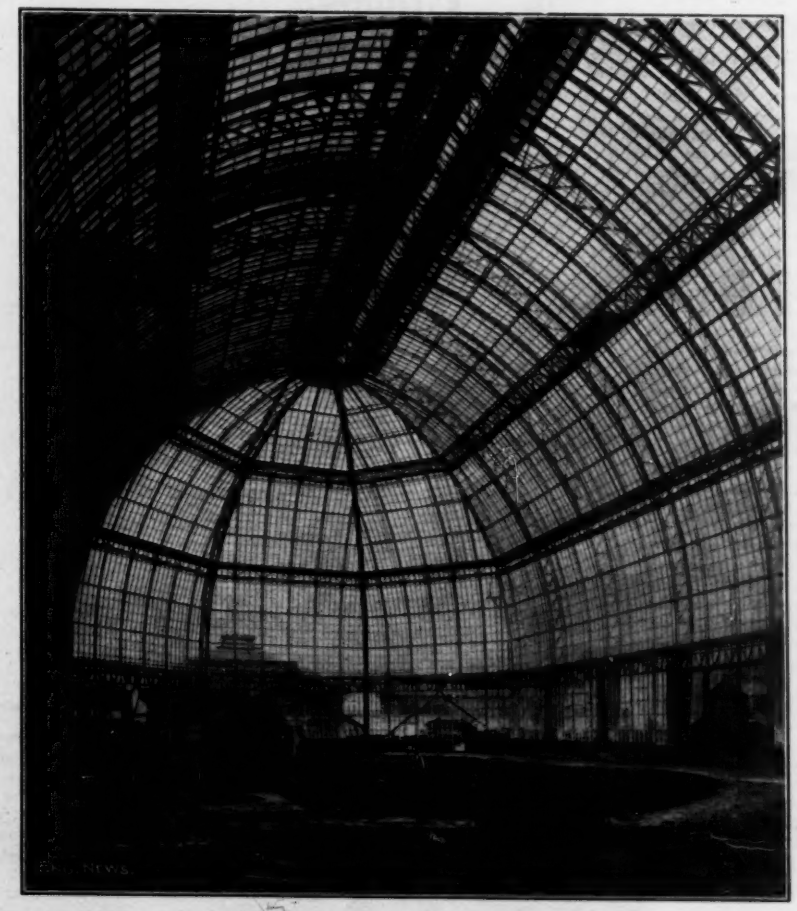
	Page.
EDITORIAL	315
Municipal Consolidation or Intermunicipal Cooperation—A Case Where Cooling a Boiler Furnace Increased the Efficiency—An Unwise Extension of Federal Supervision—Who Can Be Expected to Plant Trees for Use Fifty Years Hence?	
Town Planning, Housing and Sanitary Reforms in Great Britain	316
LETTERS TO THE EDITOR	316
The "Laws of Friction" Not Yet Upset; Frank S. Bailey; M. M. Caldwell—Problem of a Circular Girder with Torsion Bracing (illustrated); G. S. Yates—A Bill to Make Civil Engineering a Close Profession in the State of New York; Walter G. Eliot—Friction in Delivery Pipe Lines from Hydraulic Dredges; H. S. Wood, M. Am. Soc. C. E.—Notes and Queries.	
ENGINEERING NEWS OF THE WEEK	325
PERSONALS	326
ENGINEERING SOCIETIES	326
ENGINEERING LITERATURE SUPPLEMENT	29

Inside-Glazed Greenhouses in the Berlin Botanical Gardens.

During the last few years the Royal Botanical Garden in Berlin has been moved to a less crowded and more rural region, in the royal park Dahlem, near Steglitz, suburb of Berlin. The new buildings erected here to accommodate the exotic plants are interesting structures in several respects, but chiefly because inside glazing has been employed, to protect the steel framework. Most prominent among them is a very large steel-arch house for tropical plants (Figs. 1 and 2), though some of the smaller buildings are also notable. A description of the new gardens appeared in the semi-official "Zeitschrift für Bauwesen" during 1909, and from this journal we reproduce the illustrations Figs. 1 to 6 herewith, showing some features of these buildings.

Inside glazing was adopted for those greenhouses in which fairly high temperature and moist atmosphere would prevail. Its purpose is not only to reduce the attack of rust, but also to make it possible to do successful repainting, inspection, etc., without interfering with the plants inside. It was desired also to get a maximum amount of sunlight, uniformly distributed, which is better attained with framing outside because the shadows cast by the frame are considerably diffused by the glass. Still another feature of merit, of some importance, is that the whole interior is a clear unencumbered space which offers no obstruction to the spread of plants within, such as inside trusses and bracing would necessarily present.

The arrangement and main details of the framing of the large tropical tree house will be quite evident from the sectional drawing Fig. 2, while the general effect is conveyed in the photographic view Fig. 2. The main arches, spanning about 100 ft. with a rise of 77 ft., are three-hinged, of such outline however as to give substantially vertical sides for a considerable height, therefore also affording good headroom over the whole floor-area. The ends of the house are hipped to half-hexagonal ground-plan of the same profile as the sides, instead of having vertical gable walls.



INTERIOR VIEW OF THE LARGE HOUSE FOR TROPICAL PLANTS, BERLIN BOTANICAL GARDENS; BEFORE OCCUPATION.

(Trusses and all other framing are outside of the glass roof, to remove them from the action of the moist interior atmosphere.)

The arch trusses are spaced about 20½ ft. apart. The main purlins are two-plane lattice girders (of triangular section), spaced 23 ft. apart, making a total of four purlins on each side. Each purlin was detailed with one of its planes horizontal, and a footwalk is laid in this plane. From these walks the outside roller shades provided for screening the upper three-quarters of the glass enclosure are operated, and the glazing can be reached for cleaning or repairing. Two intermediate I-beam jack-rafters in each bay provide means for attaching the secondary purlins, which are single Z-bars, suspended by hanger castings from the trusses and jack-rafters as explained by the detail Fig. 3. The Z-bars virtually form a part of the skylight frame, and are the only parts of the steel framework which lie inside the glazing.

Other elements of the building and equipment may be read from Fig. 2, as the inside screening for the lower part of the walls, the traveling ladder for reaching the two tiers of heating pipes hung from the trusses, and the longitudinal passage containing radiators for heating air supplied to the building. The floor was elaborated with special care, to get thorough drainage, good soil, aeration of the soil, etc. The ground was excavated 10 to 15 ft. deep, the bottom shaped in furrows and ridges, and concrete drainage gutters laid in the furrows; dry stone walls covered with sods were built over both gutters and ridges to facilitate drainage and allow the air from the outfall to enter the ground. The drains were led off to an open water course and not to the sewers, so as to avoid all chance of impregnating the ground with impure air (which it was feared might affect the plant growth unfavorably). The heater passage surrounding the whole body of soil protects it against chilling.

Two smaller buildings, one having outside glazing, the other inside glazing similar to that of the large house, are shown in section by Figs. 4 and 5. The higher building, Fig. 4, is a small house, of about 1,500 sq. ft. floor area, and is intended for tropical and sub-tropical ferns. It is interesting as an example of the excellent rigid-frame type of construction much used in mill-building work in continental Europe. Fig. 5 is a house for *Araceae*, and has a floor area of about 3,000 sq. ft. Here the rigid-frame construction is also used, together with inside glazing and outside shades.

As a parallel to the view Fig. 1, the interior effect of a smaller inside-glazed house is shown in Fig. 6. The trusses supporting the enclosure appear faintly through the glass. This house is devoted to tropical water-plants, and has for example a large tank for growing *Victoria regia*. One end of the building has a gable wall, with a large window to give a view without into a miniature tropical swamp landscape. The other end is hipped to a polygonal outline, as Fig. 6 shows. This building by nature of its use evidently has a specially moist atmosphere, so that the inside-glazed construction is particularly suitable as protecting the framework against deterioration of the paint and rusting.

Dangers Arising from the Transportation and Storage of Ferro-Silicon.

Attention has been directed recently in this country to a few cases of dangerous illness in persons employed where ferro-silicon was transported or stored. Greater attention has been attracted to the dangers accompanying the use of this material abroad than here, and particularly in England and France. In England, official attention was first given in September, 1907, when the Board of Trade warned shipowners and officers engaged in its transportation. Since the death of five Russian emigrants on the steamship "Ashton", loaded with ferro-silicon, in December, 1908, the Local Government Board has been making a prolonged study of the properties of this material. The board's report has just been issued and from an abstract of it, in the London "Engineer," Feb. 11, the following important paragraphs have been taken. A commission of French manufacturers also made an investigation along similar lines, their findings (reported in "La Lumiere Electrique," Dec. 11, 1909,) corroborating those of the English Board.

The danger manifests itself in two ways, both, however, traceable to the same cause, viz., the evolution of an inflammable and poisonous gas, of which hydrogen phosphide, (PH_3) is the chief constituent. During the handling of closed casks containing the material there have been several instances of violent explosions, the cause of which is attributed to the heat generated by friction between the lumps of ferro-silicon. More important and more frequent disasters have arisen, however, from the poisonous effects of the gases evolved from the substance when it is carried in other than air-tight cases.

Ferro-silicon is an alloy of iron and silicon, but it would appear that no chemical union exists between its two essential constituents. The percentage composition has wide variations and, among manufacturers and users, the substance is classified according to the amount of silicon present. This varies from the "low grade," containing not more than 15%, through all combinations to that known as "high grade," containing as much as 90% of silicon. The low grade variety is made in this country (England) to a considerable extent, the temperatures obtainable in a blast furnace being sufficient for its manufacture. For the higher grades a higher temperature, 1,800-2,000° C., is required, and at present our supplies are almost exclusively derived from France, Austria, Scandinavia, and elsewhere where water-power is available as a source of heat in electric furnaces. The low grade varieties have in recent years been largely discarded in the steel-making industry in place of the higher grades of foreign material, 4,000 tons of which are said to be imported annually (into England). It is just these higher grades that are dangerous, the lower, containing up to 30% silicon, apparently having little effect on the health of those handling it.

The electric furnaces used abroad in the manufacture of the higher grades usually consist of an iron casing lined with firebrick, the inner surface of which is frequently coated with a paste of graphite. The electrodes are likewise of graphite, the lower one being sunk flush with the hearth and forming part of it, while the upper electrode can be adjusted in position and is usually water-cooled. Anything from 250 to 800 HP. may be employed in these furnaces, the voltage ranging from 40 to 75 and the current from 10,500 to 15,000 amps. These furnaces are run continuously for an average period of two years, and when so running are tapped at intervals of one or two hours. In the earlier days of the industry the furnace charge consisted of iron pyrites (or other iron ore), siliceous material (such as quartzite, or sand) and carbon in the form of charcoal, coal or coke. Lime was further added as a flux to remove the slag produced by the reduction of the silica and the impurities of the iron ore. This method of working gave a high percentage of impurities in the final product, the chief of these being phosphorus and sulphur.

In the later processes, scrap iron or steel shavings are substituted for the iron ore, and quartzite is used exclusively. The addition of lime is now unnecessary, in view of the small quantity of slag produced. This last change may have important effects, as some investigators have advanced the theory that the presence or absence of calcium in the product has a large influence on the generation of dangerous gases. Thus, rock containing 96%, or even more, silica is almost always accompanied with a considerable percentage of calcium phosphate. In the reducing atmosphere of the electric furnace this becomes changed to calcium phosphide, and under the influence of moisture this gives off hydrogen phosphide.

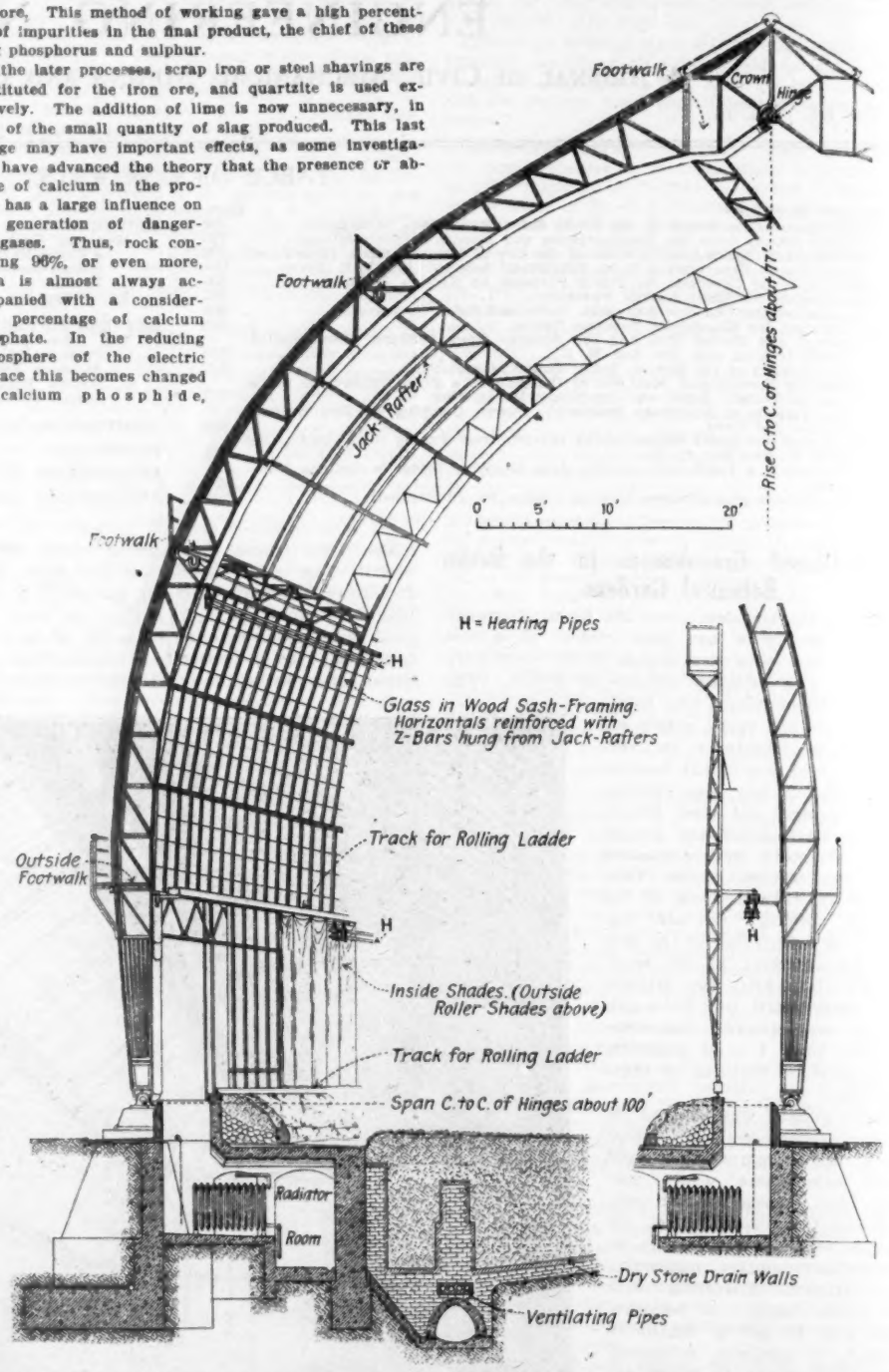


FIG. 2. HALF CROSS-SECTION OF LARGE TROPICAL BUILDING; INTERMEDIATE FRAMING AND GLAZING SHOWN IN SEMI-PERSPECTIVE.

The chemical action taking place within the furnace may be briefly stated as the reduction of the silica by the carbon with the formation of carbon monoxide, thus:

$$SiO_2 + 2C = Si + 2CO$$

Thereafter the molten silicon alloys with the molten iron, so that any desired percentage of silicon in the product may be obtained by altering the amount of iron charged into the furnace. The molten alloy is run off and cast into sand molds, a stick of "green" wood being used to remove the slag which floats to the top. When the pig has cooled, it is broken up into suitably sized pieces under a hammer. In some cases it is the practice of the makers to dip these pieces, before quite cold, into a bath of kerosene oil or melted paraffin, the idea being to avoid contact of the substance with the air, thereby reducing its tendency to disintegrate and give off poisonous gases. But such precaution merely shifts the seat of danger from the ship's hold to the ironworks. For it is necessary, or, at least, thought desirable, to remove this coating by heating the substance before adding it to a bath of molten steel. The men so engaged, therefore, run serious risks from the gases which at this time must be driven off. It is recommended that this process of "pickling" should be abandoned. Under the keen competition existing among manufacturers of ferro-silicon the material is packed into barrels and despatched to its destination as soon as its condition admits. This may in part explain the presence of a certain amount of hydrogen phosphide and arsenide, as a prolonged exposure to the air has the effect of driving off a large proportion of these gases. It is further recommended that all ferro-silicon should be stored at the maker's works for at least a month after it is made, and in such a way that the atmosphere has full access to it.

Ferro-silicon is a metallic appearing substance, varying in color from an iron gray in the low grades to a steel blue in the higher. In samples having 10 to 35% and 60 to 90% silicon the mass is close and free from bubble cavities, but, in the intermediate grades, the presence of cavities is characteristic and the texture is coarser. As a result of these researches it is held that

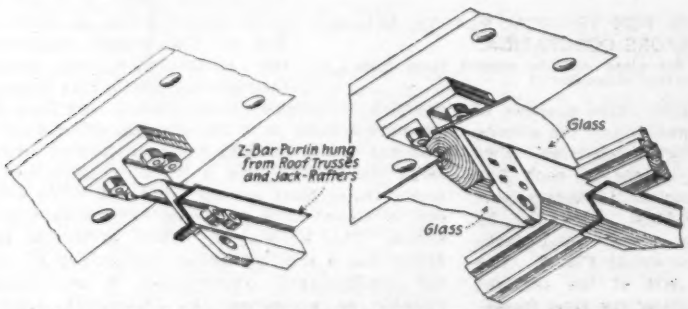


FIG. 3. DETAILS OF HANGER SUPPORT OF Z-BAR PURLINS AND WOOD SKYLIGHT FRAMING.

the intermediate grades evolve the poisonous gases, but that the higher grades are not free from such action, while the lower grades are practically harmless.

The volume of combined hydrogen phosphide and arsenide evolved from a ton of ferro-silicon was found to be as great as 16.4 cu. ft. for a sample having 42% silicon and 15.8 cu. ft. for a sample having 52%. In the high grades (60 to 96% silicon) the gas evolves varied from 1.0 to 5.7 cu. ft. The danger is seen when it is remembered that 0.025% of hydrogen phosphide in air is fatal to humans. The intermediate varieties probably owe their increased quantities of gas to the occlusion of a certain amount of hydrogen phosphide in the pores and blow-holes characteristic of these grades. Such gas would be given off when the substance disintegrated, in addition to that generated by the action of moisture on the calcium phosphide present as an impurity. Such phosphide is derived from the calcium phosphate initially present in the raw materials, and samples of quartz and of coal or coke from the stocks of different manufacturers showed that calcium phosphate was found in considerable quantities. The evolution of hydrogen arsenide is attributable to arsenic, which is likewise liable to be present in various forms in coal and iron with a consequent formation of calcium arsenide in the electric furnace.

The functions of ferro-silicon in steel making are similar to those of spiegeleisen or ferro-manganese. In cast iron, the presence of silicon has well-marked effects, and as a convenient form in which to add this element ferro-silicon has long been used. In steel making, silicon is employed for its action as a metallurgical fuel, thereby allowing the molten mass to remain liquid for sufficient length of time to permit thin and intricate castings to be made. Further, it acts as a reducing agent, largely preventing the formation of blow-holes, and has an important influence on many of the physical properties of steel. In former days the low-grade material known as "silicious iron" was exclusively used, and apparently answered all the purposes required of it.

Since the introduction of the electrically-produced material a strong tendency has been manifested by makers towards the employment of the grades containing about 50%, apparently for no other reason than that this percentage lends itself to an easy calculation on the part of the workmen when settling how much to add to any given bath of steel. The report shows that it is just this quality from which most is to be feared, and it is suggested that the manufacture of this particular grade should be forbidden, so as to allow the use only of the varieties containing up to 30% silicon and of those containing more than 70%.

AN ELECTRIC LIGHTING CAR for use in tunnel inspection, track maintenance work, etc., has been built by the Swiss Federal Railways for their own use, as described by Mr. M. Messer in the "Schweizerische Bauzeitung" of Feb. 26. It was rebuilt from an old four-wheel passenger coach, whose body was changed over to a simple box with two rooms and a large front platform. The forward compartment, just behind the platform, is a store-room for lamps, etc. The rear compartment contains a 22-HP., vertical, four-cylinder, water-cooled gasoline motor of the type used for commercial motor-cars. This is coupled to a 13-KW. compound-wound motor by a leather coupling. The set runs at 800 r. p. m., producing current at 120 volts pressure. The front axle of the car is driven by a geared motor of 12 HP. at 120 volts. The gear is connected to the axle by a magnetic clutch, excited only when the controller is on, so that when the car is idle the axle is free; this arrangement was provided to avoid danger to the armature in case the car should be hauled by a fast train. The lighting equipment comprises a 14-in. search-light of 6½ ins. focal length, which can be set on a stand on the front platform or on a portable stand; two 10-ampere open arcs hung on brackets on the roof of the car and fitted with upward reflectors, to illuminate tunnel roofs; four arc lamps adapted to be mounted on short poles which can be set up anywhere alongside and guyed by ropes; and several panels of incandescent lamps which can be hung on the side of the car, to illuminate the side wall of a tunnel or the like. Four cable reels on the front platform provide for the supply of current to the arc lamps. The car carries gasoline storage tank having about 20 gals. capacity. At ordinary output this will run the engine for over twelve hours. The car is not intended to go long distances under its own power, but is to be hauled by trains to the station nearest the point of service. The total weight of the car is about 18 tons. It can make a speed of about 10 mi. per hr.

Air Compressor Accidents in the Transvaal.*

The accident that occurred at the Langlaagte Deep, Ltd., on March 25, 1909, was the most serious of four similar occurrences in which explosions or firing took place in the discharge pipes or receivers of air compressors. At the Crown Mines, Ltd., there was a more violent explosion, but, owing to the great damage to the pipe line, which was absolutely wrecked in several places, no dangerous gas was delivered at the working places in the mine.

In the former accident, however, the resultant fumes from the explosion were discharged through a compressed air main into the mine and caused the death of ten persons and injuries to three others.

At the Roodepoort United Main Reef, Ltd., and the Main Reef West, Ltd., there were cases of firing with no violent explosion and no more serious damage to plant than the bursting of a few of the intercooler tubes, but in each case persons underground were gassed and there was one fatality. In these two instances the low-pressure side of the compressor appeared to be the seat of the trouble, but at the Langlaagte Deep and the Crown Mines the explosion occurred at the high-pressure valve chest or in the receiver.

All these accidents were followed by complete investigation into the attendant circumstances, but in no case could the actual cause be definitely assigned. There is, however, no doubt that the explosive mixture consists of air and the gases distilled from the lubricant deposits. It is possible that these volatile constituents of the oil may also carry very fine dust, which assists in lowering the ignition temperature of the mixture. Without allowing the possibility of sparks being created or very high local temperatures being caused by friction within the cylinders of the compressor, one has to regard the failure, partial or complete, of the water supply to jackets or intercooler as the probable reason for a rise in temperature sufficiently high to ignite the hydrocarbon deposit or the explosive gases distilled from this accumulation.

It may be mentioned that many tests have been made of the lubricating oils used in the compressor cylinders and these have invariably been found to have high flash points, i. e., above 600° F. The ignition temperatures will, of course, be much higher than these flash points. The hydrocarbon deposit usually found in air receivers and pipes will burn and can be ignited with an ordinary match. In one case it was found that the carbonized matter taken from a compressor valve chest, when mixed with the lubricating oil, lowered the flash point of the latter. The substance seemed to cause a catalytic decomposition of the oil into carbon and a more combustible gas. The analysis of this substance showed 30% of mineral ash, mostly iron oxide, but with marked quantities of copper and zinc and a little potash and soda. This suggests the corrosion of iron and brass by fatty acids—probably soft soap had been occasionally used as a lubricant.

While pursuing inquiries into the causes of firing and explosions in compressors, the following additions to the Mines and Works Regulations are proposed to endeavor to prevent this class of accident:

(2) All compressed air receivers and their connections to air cylinders shall be kept clean and free from carbonized oil or other material liable to ignition, and shall be opened and examined in this respect, by the resident mechanical engineer appointed under Regulation No. ....., or other duly authorized and competent person at intervals not exceeding one month. A written record of each such inspection signed by the person making it, who shall be held responsible for compliance with this regulation, shall be in the user's possession and open to inspection by the Inspector of Machinery.

(3) Thermometers or pyrometers, the indications of which can be clearly read, shall be fitted close to the outlet valves on the discharge pipes from the cylinders of air compressors. The highest temperature allowed shall be indicated by a red mark on the scale, and the engine-driver in charge shall be responsible that this temperature is not exceeded.

*From the Annual Report of the Government Mining Engineer for the year ending June 30, 1909. See also Eng. News., Vol. Jan.-June, 1905, p. 220.

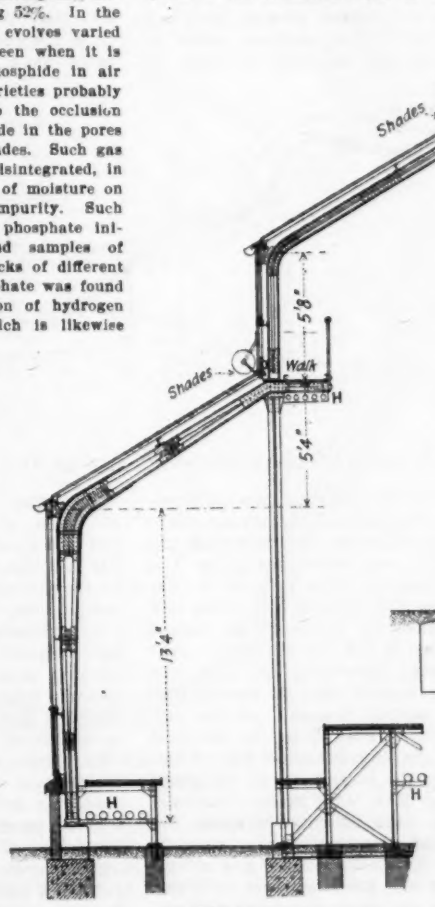


Fig. 4.

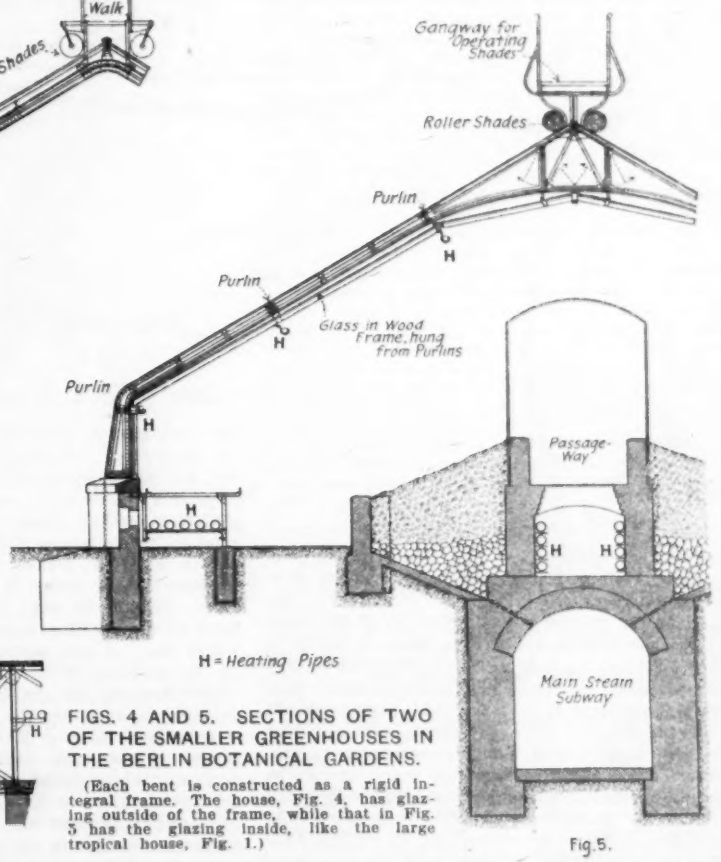


Fig. 5.

FIGS. 4 AND 5. SECTIONS OF TWO OF THE SMALLER GREENHOUSES IN THE BERLIN BOTANICAL GARDENS.

(Each bent is constructed as a rigid integral frame. The house, Fig. 4, has glazing outside of the frame, while that in Fig. 5 has the glazing inside, like the large tropical house, Fig. 1.)

Fig. 6. Inside-glazed Greenhouse for Tropical Aquatic Plants, Berlin Botanical Gardens.

The Nisqually Hydro-Electric Plant of the City of Tacoma Washington.

The electric light and power distributing system in Tacoma is owned by the municipality which buys electric power at wholesale from the Seattle-Tacoma Power Co., for street lighting, for pumping water for the city water works, and for distribution in the city to light and power customers. The power is secured, under four contracts aggregating 6720 KW. which run until the latter part of 1912. The rate is 1.25 cts. per KW.-hr., for 5,600 KW. and $26.80 per KW.-year for the balance which is used for pumping water. The contract for energy for pumping, at this last rate, provided that such power was not to be used during certain hours of the day when the power company was carrying a peak load. As this arrangement prevented continuous operation of the water-works pumps, a supplementary contract was made which permitted the supply of 1340 KW. continuously. For this continuous service the city pays $850 per month additional whether the power is drawn or not during these hours. This brings the cost of power for pumping higher. For instance, if the full amount contracted for for pumping is drawn the average cost is about $29.10 per KW.-year. The present load factor (ratio of average load to maximum demand) is from 25 to 30%.

In January, 1909, the city, at a special election, authorized the construction of a $2,000,000 municipal power plant. The site selected is on the Nisqually River about 30 miles southeast of the city. The Tacoma Eastern R. R., recently purchased by the Chicago, Milwaukee and Puget Sound Railway Co., runs near the site.

The Nisqually River heads in the glaciers on the southern slope of Mount Tacoma. The upper part of the river has a heavy fall and during high water it carries large amounts of drift and sand which have to be considered in any development. At the site selected by the city, the river flows through a deep rocky gorge and has a fall of 420 ft. in a distance along the river of three and one-half miles. The river has a minimum flow of about 300 cu. ft. per sec., and a normal low water flow of 400 cu. ft. per sec. The lowest water occurs from August to November. The intake will be 970 ft. above sea level.

Surveys of the site were started in March and completed in October, 1909. The lands and rights necessary for the construction of the plant have been condemned by the city and secured at a cost of $200,000. Plans have been made for the plant and bids have been called for on the headworks and tunnel, which it is estimated will take about two years to complete. Contracts will be let during the year for the balance of the work and for the machinery and electrical equipment, including a transmission line and a substation in the city. The proposed development is shown in general by Fig. 1, and more in detail in the following figures. There will be a concrete diverting dam, 260 ft. long on the crest and 45 ft. high at the center. At right angles to the river is the intake. The provisions for getting rid of drift and sand may be seen from Fig. 2 and from Figs. 4 to 11. At the intake entrance is a floating boom to keep out drift. This boom moves in guides and is provided with rollers to prevent sticking during a change in water level. The washout gates, at the left of the dam, are provided to sluice off silt and gravel which may accumulate in front of the screens. At the head of the intake channel are three regulating gates for controlling the flow into the channel, and below the gates is a concrete settling channel. The bottom of this channel has a heavy fall towards the lower end which is 11 ft. below the grade of the tunnel through which water is led for the power station. It will be seen, from Fig. 10, that the floor of the sluicing branch itself is several feet below that of the conduit branch. At the end of the sluicing channel (Figs. 8 to 11), are two washout gates for sluicing the sand out of the settling channel into the river. All of the gates will be made of cast iron, with bronze bearings, double stems, and with gearing designed for both motor and hand operation.

In Figs. 4, 6 and 7, will be noticed a 4 × 7-ft. passageway through the diverting dam with one stair approach from the right wing wall and another from the house over the regulating gates. From this passageway 6-in. steel pipes lead to the down stream face of the dam to admit air under the falling sheet of water.

From the settling channel the water will flow through a tunnel 10,015 ft. long. The tunnel will be lined with concrete and will be 8.5 ft. wide and 9.5 ft. high from the bottom to the inside of the arch. The grade of the tunnel is 0.20%. It was decided to construct such a tunnel instead of a flume following the grade through the canyon as the tunnel would be permanent and as there would be less danger of interruption to the service. The flume line would run along a steep side hill where there would be danger from slides and falling timber.

From the lower end of the tunnel the water will be carried over the Nisqually Canyon in a 10-ft. riveted steel pipe on a 360 ft. bridge, consisting of two 80 ft. deck spans and one 200 ft. steel arch span, with a rise of 40 ft. The bridge will be 340 ft. above the river.

From the end of the 10 ft. steel pipe, the water will flow through a reinforced-concrete conduit to a concrete regulating reservoir, which is located on a mesa immediately above the power house. This reservoir will have an area of about six acres, an available storage depth of 12 ft. and will furnish sufficient water to generate 10,000 HP. for three hours. The reservoir created by the diverting dam will have an area of thirty-seven acres, and an available storage depth of 5 ft. equivalent to 172 acre feet. Both reservoirs are designed to enable the generating plant to carry a large peak load during the low-water season. Provision is made in the construction of the dam for storing an additional depth of 4 ft. by means of flashboards on the crest.

The walls of the regulating reservoir will be of concrete in sections about 40 ft. long, with expansion joints between sections, and backed with an earth embankment. The bottom of the reservoir will be lined with concrete 6 ins. thick put in in blocks, about 20 ft. square, with asphaltum expansion joints. The bottom of the reservoir will slope towards the center and toward the washout gates to facilitate cleaning. On the upper side of the reservoir an inlet channel is provided connecting with a waste and overflow channel running to the river. When the gates are open the water will flow past the reservoir and when the gates are closed the water will rise and spill over the inlet weir into the reservoir. This weir below the gates serves as an overflow for the reservoir.

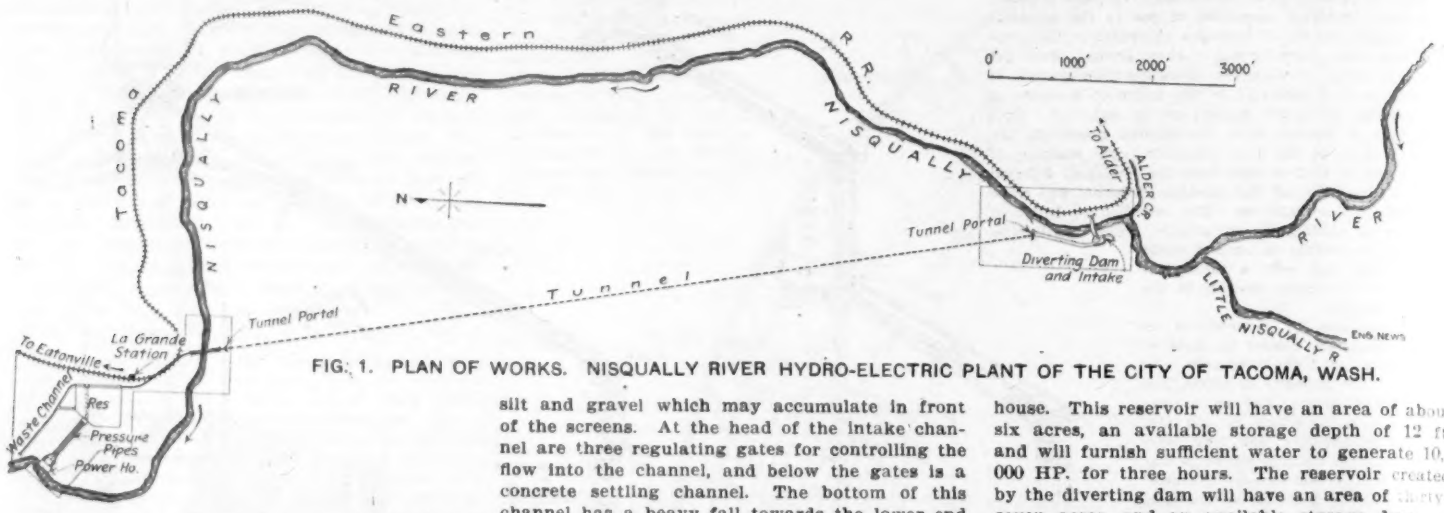


FIG. 1. PLAN OF WORKS. NISQUALLY RIVER HYDRO-ELECTRIC PLANT OF THE CITY OF TACOMA, WASH.

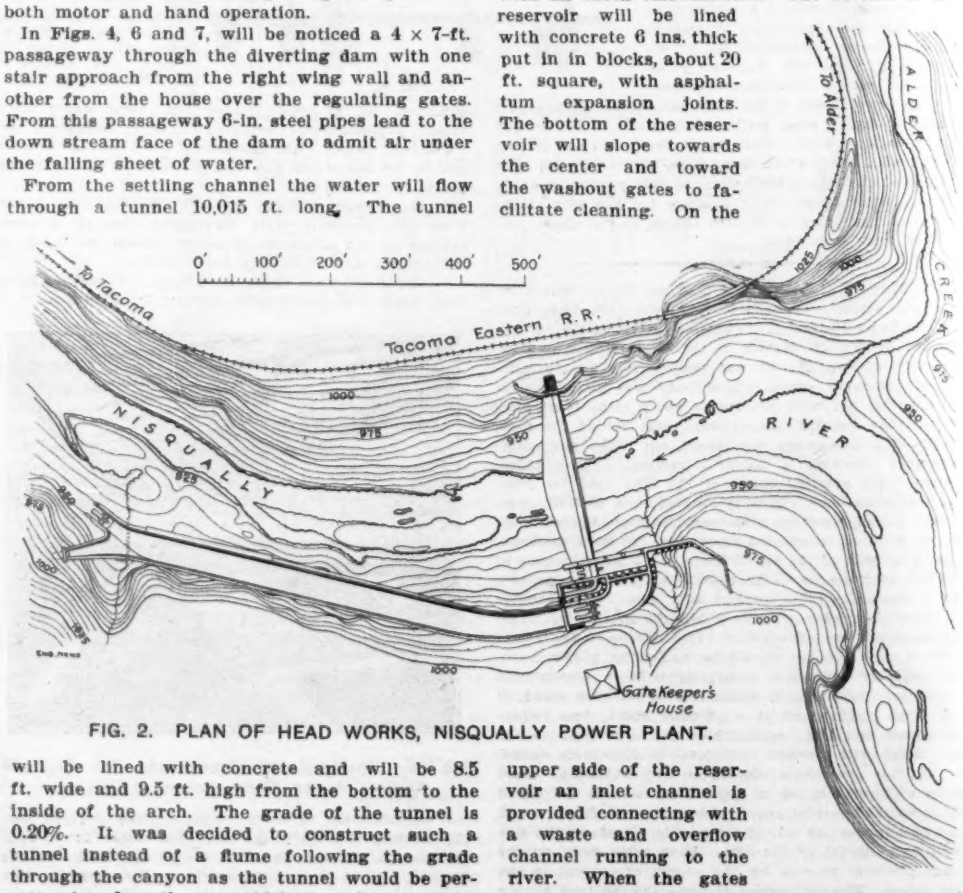


FIG. 2. PLAN OF HEAD WORKS, NISQUALLY POWER PLANT.

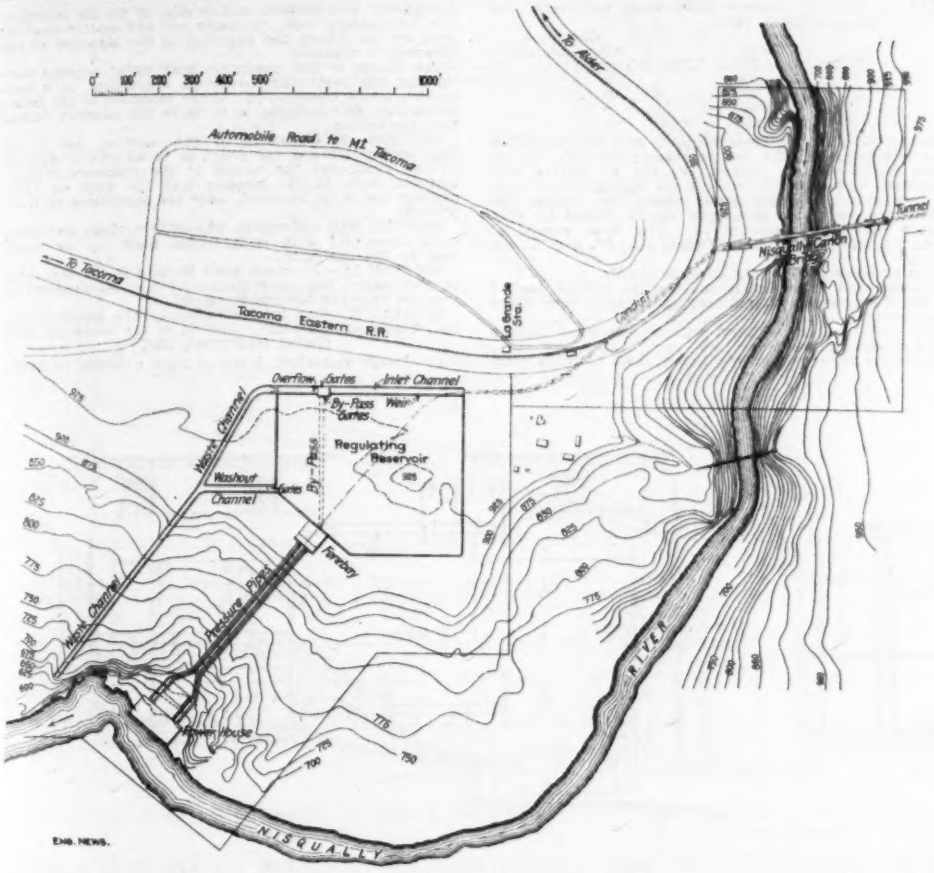


FIG. 3. PLAN OF REGULATING RESERVOIRS AND POWER HOUSE, NISQUALLY RIVER DEVELOPMENT.

A by-pass channel under the reservoir will connect the inlet channel with the forebay for supplying water to the plant when the reservoir is emptied for cleaning. The forebay will be of concrete with screens and regulating gates at the head of the pressure pipes. The gates at the reservoir will be similar in design to those at the headworks and will be motor operated. The gates at the head of the pressure pipes will be controlled from the power house switchboard.

The pressure pipes from the forebay to the power house will be of riveted steel, supported on steel saddles and concrete piers. There will be four main pipes, one for each generating unit, and one pipe for the two exciter units. This last pipe branches at the power house and is cross connected to two of the main pipes. Expansion joints will be used in all of the pipes.

The power house will be constructed of concrete and brick, with steel roof trusses and a tile roof. The low-tension switching room, transformer room and the high-tension switching room will be on the upper side of the main building and at a higher level than the operating floor. The power house equipment will consist of four 10,000 HP., horizontal-shaft, double-discharge, turbine wheels connected to 5,000-KW. three-phase, 60-cycle, 6,600-volt, generators. Two 300-KW. exciters will be connected to impulse wheels. There will be four banks of single-phase transformers with the necessary equipment of low and high-tension, electrically operated, oil switches.

The transmission line from the power plant to the city will be double, on wood poles and will be about 30 miles long. The line voltage will be 60,000. There will also be a three-wire, three-phase, 6,600-volt line from the station to the headworks and 220-volt line from the regulating-gate house to the gates on the settling channel.

A new substation will be constructed in Tacoma at South Twenty-fifth and C Sts. It will be of stone and brick, with two floors. The electrical equipment here will consist of electrically operated, oil-break switches, four banks of single-phase transformers, arc-light transformers, regulators, switchboards, etc. At the north end of the substation will be a material yard and store house, the buildings and yard occupying an entire block. Current will be distributed about Tacoma by a three-phase, four-wire, 2,300/4,000-volt system. All conductors from the substation to the street will be carried underground through tunnels and conduits.

The surveys of the site and the design of the several structures for the proposed development were made under the direction of Mr. Frank C. Kelsey, Chief Engineer, to whom we are indebted for information and plans.

Twenty Years' Experience with an Employees' Advisory Board.*

By E. BLUM.†

In 1888, on the initiative of Mr. Wilhelm von Oechelhaeuser of its executive committee, the Berlin-Anhaltische Maschinenbau Co. first instituted an Employees' Advisory Board as an experiment. Mr. Von Oechelhaeuser held that such an institution would have a tendency to further an amicable adjustment in all questions arising between employer and employee. He himself drew up the governing rules and assisted with his advice in organizing the first attempt. The rules then drawn up were accepted by a meeting of the workmen of our factory at Dessau on Feb. 21, 1888, and immediately went into force for that factory. The Board thus formed (then known as "Aeltesten-Kollegium," i. e. Senior Council) has existed ever since that time, and the rules governing it have remained unchanged.‡

Not long after this period we introduced the same institution into our Berlin (Moabit) factory, changing the name Senior Council to Employees' Advisory Board, which designation we have retained since, and which, perhaps, expresses the duties of such a body better than the now common term Employees' Committee. The work of the Board is, in fact, advisory. I have always regarded it as such, and in consequence have had fully as good results with the institution during the 20 years now past as the Management of our Dessau factory has experienced. In Berlin the governing rules were later amended, chiefly on the basis of the experience of the Siemens-Schuckert works with ticket elections, which give due representation in the elections to the several groups or parties among the workmen.

The rules now in force at our Berlin factory are as follows:

GOVERNING RULES OF THE PERMANENT ADVISORY BOARD OF EMPLOYEES OF THE BERLIN-ANHALTISCHE MASCHINENBAU CO., BERLIN.

SECTION I.—The Permanent Advisory Board of Employees is charged with the duty of advancing the interests of the employees by peaceable cooperation with the company, and of giving good counsel and example to the other employees in this direction. In particular it has the following duties:

a.—To uphold integrity, good order and proper conduct in the shops, and to discourage drinking and malingering.

b.—To work for proper maintenance of the shop rules,

*Translated and abstracted from the "Technik und Wirtschaft" supplement to the "Zeitschrift des Vereines deutscher Inginieure" of November, 1909.

†General Manager, Berlin-Anhaltische Maschinenbau A. G., Wilmersdorf near Berlin, Germany.

‡The rules, quoted in full in the original which we have here translated, do not differ essentially from those of the Berlin factory, quoted farther on. The chief differences are in the number of members (4 at Dessau, 7 at Berlin), in the period of employment necessary for the ballot, and in the manner of election. At Dessau there is ordinary balloting for 2 members in machine shop and pattern room, and 2 members in foundry and cleaning room, against the intricate system of ticket nominations adopted in the Berlin factory. At Dessau all employees over 21 and in full possession of civil rights can vote, while at Berlin one year's employment is a further condition. In both factories, candidates for the Board must be at least 30 years old, and at least three years employed in the factory.—Ed.

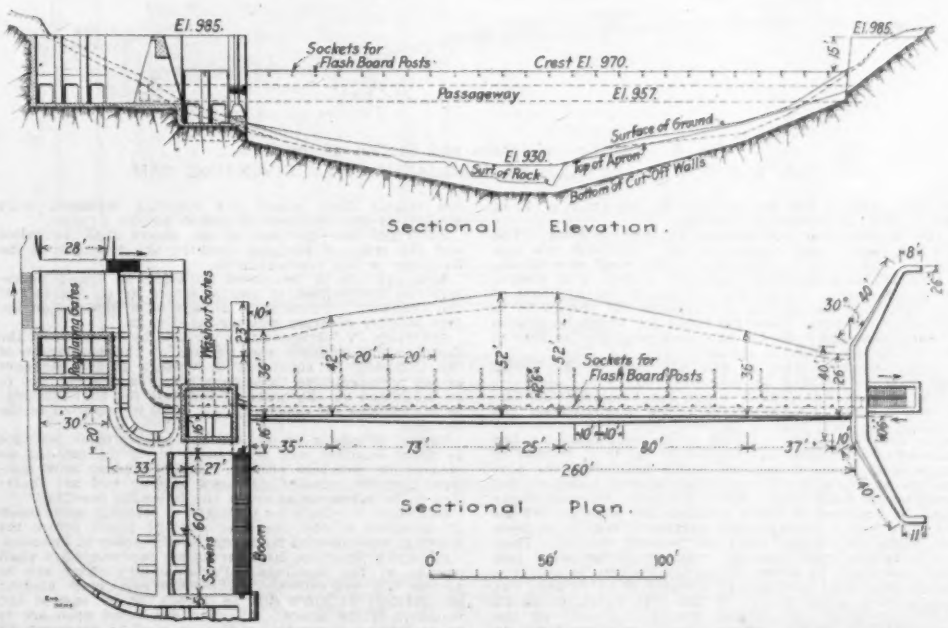


FIG. 4. DIVERTING DAM, NISQUALLY RIVER POWER DEVELOPMENT.

and compliance with all instructions for accident prevention and other instructions issued in the interests of or to protect the health or safety of employees.

c.—To deliberate on and give opinion on all questions affecting the welfare of employees and the prosperity of the business which may be submitted to it by the Management.

d.—To cooperate in the management, supervision and extension of all institutions and arrangements for the welfare of the employees and their families, within such limits as may be set by the Management.

e.—To take charge of the employees' excursions, balls, public performances, etc.

The Advisory Board may delegate special duties to individual members, and may call in other employees to assist confidentially in its deliberations.

SECTION II.—To give proper representation to the diverse elements among the employees, a separate nomination ticket may be prepared by each group, union or society among them and by the unattached employees. Each ticket may name seven candidates, and must be written on a nomination blank which the Management will issue three weeks before the date of election.

Candidates must be employees who have been in the Works at least three years and who are at least 30 years old, and must signify their acceptance of the nomination in writing on the nomination ticket. A candidate nominated on several tickets is to be considered as nominated only on the ticket filed first.

Each ticket must designate one man to deal with the Works Management.

The tickets must be filed with the Works Management at least ten days before the date of election. They will be numbered by the Management in the order of filing and will be published by posting.

The Management will appoint an election clerk. The election board shall consist of the clerk and two employees chosen by acclamation at the beginning of the election. Each employee entitled to vote will receive from the clerk a voting slip containing the numbers of the published nomination tickets, and the elector is to underline the number of that ticket for which he desires to vote. The slip must not be signed, and is to be handed to the election clerk in person.

Every employee over 21 who has been in the Works one year is entitled to vote.

The election board shall count the votes for the different tickets. The result is to be computed on the basis of the total number of votes cast. The number of votes cast for each ticket is to be multiplied by the number of candidates and divided by the total number of votes cast, giving a quotient which represents the proportion of places which would fall to each ticket on the basis of the votes cast. These computed representations shall be reduced to whole numbers by striking out all fractions, and a corresponding number of candidates from the respective tickets shall be declared elected. Then the tickets whose computed representations were less than one shall, in order of magnitude, receive one representative each, until a total number of seven men has been elected to the Board. If this still leaves the Board less than seven, the largest fractions crossed off the representation of the tickets already considered are to receive one representative each, in the order of magnitude.

[As an example, suppose 3,500 votes were cast, distributed over five tickets thus:

	Votes.		Computed representation.
Ticket I.,	1,350 ÷ 3,500,	× 7	= 2.7
" II.,	950	"	= 1.9
" III.,	750	"	= 1.5
" IV.,	300	"	= 0.6
" V.,	150	"	= 0.3

Crossing off fractions gives Ticket I. two representatives and Tickets II. and III. one representative each, leaving three places vacant. Tickets IV. and V., having only fractional representation, receive one representative each. As this still leaves one place vacant, the highest discarded fraction of the first three tickets (Ticket II., 0.9), counts for one representative. The final result is: Tickets I. and II., two each; Tickets III., IV. and V., one each).

Two or more parties may combine tickets.

Contests and objections to the election will be decided by the Management, after a hearing of the election board if necessary.

The result of the election will be published by the Management by posting.

Vacancies occurring in the Board shall be filled from the tickets from which the vacating members were elected, in the sequence of names on the tickets.

SECTION III.—Meetings of the Board shall be called and the order of business fixed by the Manager of the Company or his representative.

Meetings are to be called as often as found necessary, on the request of two members or on the call of the chairman. There shall always be a meeting on the first Monday of every quarter, at 6 p. m.

SECTION IV.—Proposals or motions by members of the Board which concern the welfare of the employees of the Company, if submitted in writing to the Manager or his representative three days before a meeting, are to be scheduled on the order of business for that meeting; or the reasons for omitting them shall be reported at the meeting.

Urgent proposals or motions not submitted in advance as above required may be brought up in the meeting on vote of the members present. Resolutions on such matters, however, require a second reading and are therefore to be taken up again in the following meeting.

SECTION V.—Calls for meetings, in writing, must reach all members of the Board at least 24 hours before the meeting, accompanied by a copy of the order of business.

SECTION VI.—The Manager or his representative shall preside at the meetings. Parliamentary rules are to govern all proceedings. The chairman may present the matters of discussion in person or by one of the members of the Board. All questions voted upon are to be so framed if possible that they may be answered by "yes" or "no."

Three members shall constitute a quorum of the Board. A majority vote decides, and in case of tie the chairman has the deciding vote. To carry out any matter resolved upon by the Board, the approval of the Manager of the Company is required.

The Board or the chairman may order secrecy concerning any particular matter or resolution. In a proceeding which concerns one of the members of the Board personally, this member is to leave the meeting during that proceeding.

SECTION VII.—Minutes of the meeting are to be kept by a member of the Board or by an official detailed by the Company; the names of the members present, motions made in the meeting and the vote on the motions are to be recorded, over the signatures of those present.

SECTION VIII.—Members who violate these governing rules repeatedly may be excluded from further meetings by the chairman.

SECTION IX.—Elections shall be held in the last week of November. The confirmation of the Management is required to make the result official.

SECTION X.—The term of office of the Board begins Dec. 1 and continues until Nov. 31 of the following year.

(Dated November, 1907.)

As already remarked, I regard such a Board as advisory to the employer. On the basis of our experience with it in the past 20 years, I can say that the institution has fully justified its existence. To-day we would not willingly do without it. Many troublesome sources of dispute are removed by virtue of the periodical discussion of all appropriate business and personal matters. Certain items of the order of business are brought up for renewed discussion at regular and not too infrequent intervals.

WORK OF THE BOARD.—Among the subjects discussed by the Board are the following: Shop rules; Working hours; Welfare arrangements of all kinds; Various improvements in the shops; Wage questions; Purchase of provisions and other domestic supplies; Care of the dependent; Supervision of the company store; Supervision of the farming and gardening on our unoccupied plots of ground (these are turned over to the employees for this purpose when not needed by the Company); and supervision of many other kinds among the employees. These discussions bring about an active intercourse with our employees, which exerts a distinctly favorable influence on the conduct of the business.

We have not had a single serious conflict with our employees during this whole period. All points which might have led to grave differences of opinion were settled by early discussion and frank explanation of the circumstances. But to make this possible, it was necessary from the beginning that the leading officials of the company should concern themselves personally with the questions raised. It has always been apparent that this immediate personal intercourse between the leading officials and the employees' representatives tended toward the success of the negotiations. I myself was able, again and again, to explain to the representatives of the workmen why certain concessions which were demanded could not be made.

THE QUESTION OF OVERTIME.—For example, I was able to make clear to them in spite of the now prevalent objection of workmen to overtime, that because of the nature of our output, which makes much higher demands on our producing capacity in summer than in winter, the only means of doing away with overtime would be to enlarge our equipment capacity, and that this would necessarily mean a considerable reduction of force in winter. Although I personally am strongly opposed to overtime work and try to reduce it to the utmost, still it cannot with the best intentions be wholly avoided in a business which, like the gas business, thrives only in the few months of summer, while in winter the work of building is idle. The Board readily understood that the only equalization lies in large contracts extending over several years. When such contracts are scarce, and when the urgent summer and fall work is in excess, the need for equalizing by overtime work is self-evident.

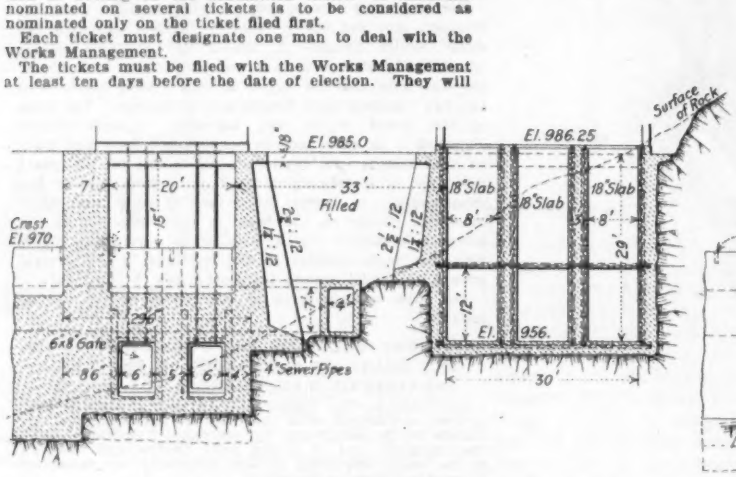


Fig. 5. Cross-Section of Regulating and Washout Gates.

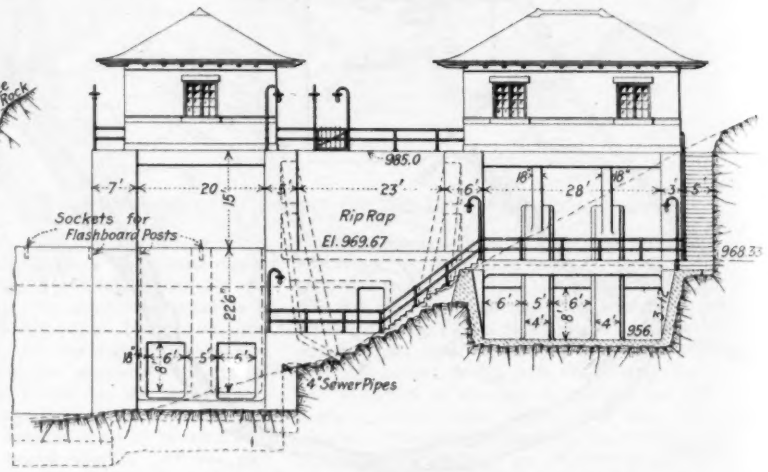


Fig. 7. Elevation of Gate Houses and Section of Settling Channel.

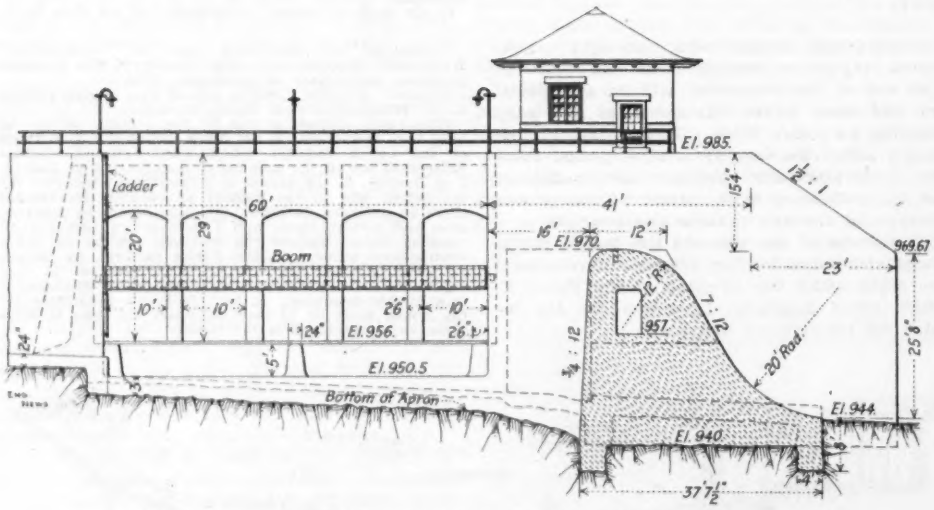


Fig. 6. Elevation of Intake and Section of the Dam.

FIGS. 5, 6 AND 7. DETAILS OF NISQUALLY RIVER DIVERTING DAM.

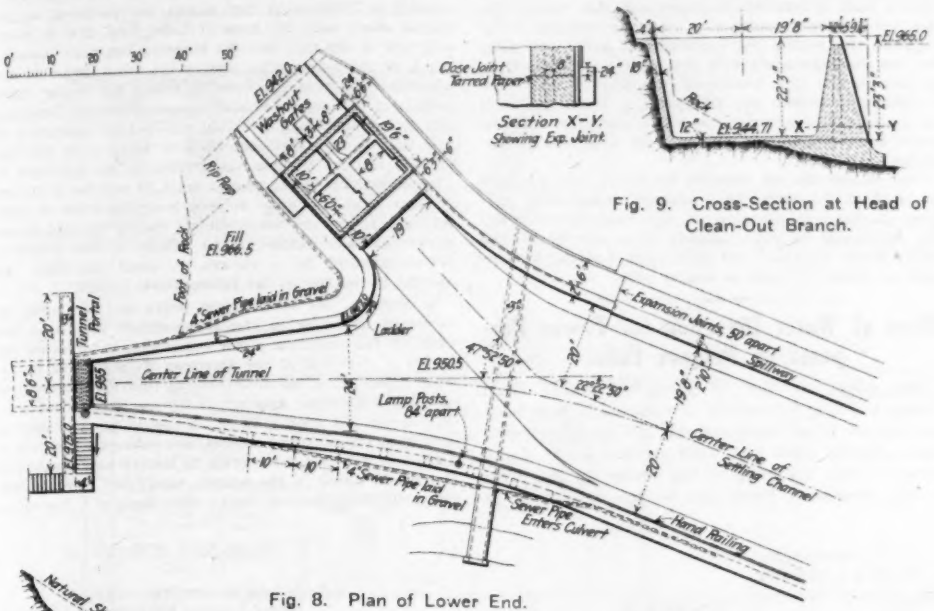


Fig. 9. Cross-Section at Head of Clean-Out Branch.

Fig. 8. Plan of Lower End.

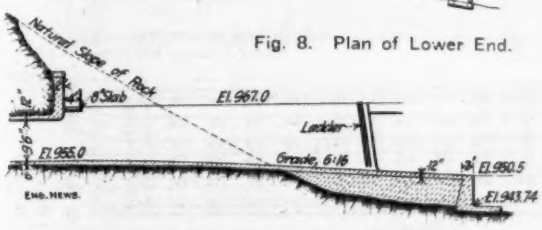


Fig. 10. Longitudinal Section of Conduit Supply Branch.

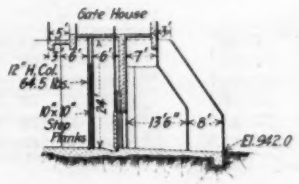


Fig. 11. Section Through Clean-Out Gates.

FIGS. 8, 9, 10 AND 11. DETAILS OF SETTLING CHANNEL, HEAD WORKS, NISQUALLY RIVER DEVELOPMENT.

The employees soon realized that, if they made trouble for us in this matter, the manufacture of stock which we carry on in winter for the purpose of keeping the shops full would not be done as extensively as now. The manufacture for stock is in fact carried on chiefly in order to give us a larger output capacity in summer by enabling us to make up certain parts of orders from stock; and on the other hand—this was successfully insisted upon to the Board—this method of working makes it possible for us to keep busy those workmen who have been with us for many years, even when the amount of business momentarily in the shop would not otherwise warrant it. I believe that every sensible employee to whom these reasons are presented in a suitable way would understand very quickly that in his own interests he must make some allowances in the matter of overtime. Curt and arbitrary methods of dealing with this problem usually achieve the contrary result. Intelligent discussion of such questions serves to educate the employees to thinking assistants, who know how to join their interest to the interest of the company.

HELPING DEPENDENTS.—Our Employees' Boards are specially charged with handling assistance to dependents. All benefits granted through the welfare arrangements which we have, require to be certified by the Board. The income of our benefit funds, together with the fines levied for disobedience of shop rules and the surplus realized in the management of the company store, are available for this use. • • • Benefits are granted only when the Employees' Board requests or authorizes it. All applications for assistance which come to the management go first to the Board for report and recommendation. This plan has worked excellently, for we have found that the Board proceeds in its investigation very impersonally, without regard to partisan interest and solely on the needs of the case. During the whole period, although the Board has frequently changed its personnel, we have been able to follow the recommendations of the Board without modification, because we could always convince ourselves of the thoroughness and objectively of the investigation. • • • Cooperation in this field brings us together mutually. The employees feel that we are desirous of developing them into cooperation with us, to help them to lead a more human existence.

Naturally this gives the Board a large opportunity to earn the confidence of the employees. Only by the most conscientious fulfillment of the duties stated above can they prove themselves worthy of the confidence of their fellow workmen. They constitute the authority which receives complaints; they reject unjustified complaints, but they also do their best to find a remedy for proper complaints.

It is evident that all these duties make a regular intercourse between Board and management absolutely essential. When the Board desires a meting, this is promptly called. If I cannot be present some other member of the management presides at the meeting. It is necessary in such meetings that the employees be left free to make their statements and explanations in full detail; all their reasons must be heard. Where their reasons do not seem sound, the attempt must be made to disprove them, and if the attempt is fairly made it will always prove possible to reach an understanding.

EMPLOYEES' COMPLAINTS.—Such occasions bring out the men's wishes, which often are very small matters. Better illumination is wanted here, a broader gangway there, or perhaps an increased number of pay-offices, so that paying off will be expedited. There are often wishes concerning the hours of recess, on which an agreement must be reached.

As all the foremen take part in the meetings of the Board, there is opportunity for reaching an understanding in cases of complaint of improper treatment on the part of the foremen. I have always emphasized in the meetings of the Board that I wished to maintain pleasant relations between foremen and workmen, and the members of the Board know very well that in cases where improper treatment is shown I will not hesitate to reprimand the foreman, and that on the other hand I will protect a foreman to the utmost against unjustified complaint.

Often there is a complaint from an individual workman that he does not earn enough in proportion to our regular wages or piece rates. Such cases are often settled in the meeting of the board by hearing the corresponding foreman. Generally, the members of the board have been wrongly informed by the complainant, and after receiving the correct explanation in the meeting they are able to set the matter straight before the workmen. Thus, it is easy to show in many cases that the man in question has the same piece-rate as others who work at similar machines, but that he earns considerably less than the others, through lack of skill or lack of experience. Pointing out such a condition spurs the man on to better effort, so that frequently he will reach the higher earning rate. • • •

INTERFERENCE WITH THE MANAGEMENT.—I do not share the often-expressed fear that an Employees' Board will establish a sort of co-regency. In the whole period I have not yet known of a single attempt of the board to influence or interfere in matters which are not explicitly assigned to its charge. It is true that often questions of wages or piece-rates have been brought up for discussion in the board meetings. Often, also, requests concerning working hours and increase of wages have been made through the board. But the members of the board recognize that in all such matters they are only intermediaries between the body of employees and the management; and, on the other hand, we appreciate fully that in these matters discussion and mutual explanation help to avoid extreme differences of opinion. • • •

THE COMPANY STORE.—The entire management of the company store is also under the supervision of the

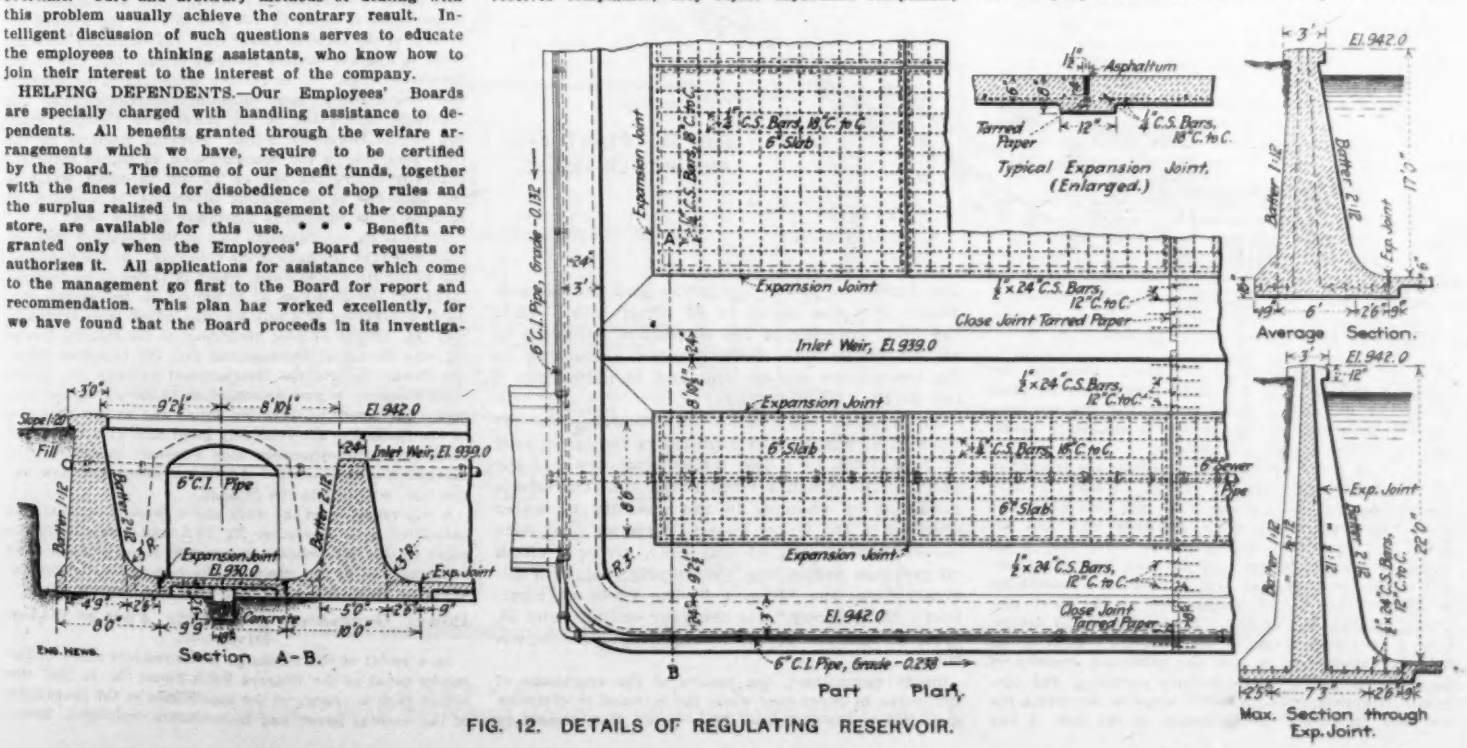


FIG. 12. DETAILS OF REGULATING RESERVOIR.

Employees' Board. Complaints about poor quality of provisions, which we often had formerly, no longer come before us. It is the board's business to say where the various supplies shall be bought, to watch over their proper condition, and, in case of complaint, to make independent investigation. We buy solely according to the directions of the board. The selling prices are fixed upon in joint conference with the board. The administration of the store thus goes on without any trouble. It yields a fair surplus, which goes into the benefit fund, as a result of which the prices fixed for the supplies are never criticized.

STOPPING BEFORE THE WHISTLE.—Formerly we could never avoid having the workmen begin washing up even before the noon hour commenced. We have only one hour intermission at noon, and it is natural that the workmen would like to leave the factory as near the stroke of 12 as possible. We often discussed this matter with the Board and finally came to an agreement on the following basis: The whistle blows 5 minutes before 12. The time between 5 minutes of 12 and 12 may be used by the workmen for washing up and dressing, but during this time they are not permitted to leave the shop or rather the washroom; then they are ready to leave the factory promptly at 12 o'clock. This plan has proved a success. The 5 minutes leeway are no great matter for us, and to make up for the loss we have reached an orderly system, which is absolutely necessary to efficient operation of the shop.

* * * I would not like to be without the institution of the Employees' Advisory Board to-day. I have always done my best to prove to the men that I have the fullest appreciation for every employee who does his duty. I have always endeavored to prove that I am trying to join the interests of the men with the interests of the Company, and that I regard the cooperation of Advisory Board and Management as the most successful solution to this end. Repeatedly in the discussions I have pointed out to the workmen that it is our duty in manufacture to raise the producing capacity of the individual workman by suitable equipment and perfection of system, whether in the shape of improving the machines, increasing cutting speeds, or the like. I was able to show by concrete examples that this view of the case has a distinct tendency to raise the earnings of the workman, by raising his performance, and I can state that the workmen agree with this view and are ready to do their part to raise producing capacity. If any course is adapted to smooth out differences in social life, it is the increase of production, in which employer and employee must cooperate equally in order to secure the desired success.

I can summarize my remarks by saying that I regard the work of the Employees' Advisory Board as a welcome assistance in carrying out the work I have to do. The experience of our Company with the Board has been entirely favorable and constitutes a strong inducement to others to adopt a similar plan.

Effect of Water Diversion for Power Purposes on Niagara Falls.

The effect of the diversion of water from Niagara Falls for power development has been determined from observations and measurements made during 1907 and 1908 by the U. S. Lake Survey. The lowering of the water on the crest of the American Falls due to the diversions of the American power companies and the Ontario Power Co. was found to be about $\frac{3}{25}$ in., while the total lowering of the Horseshoe Falls due to all diversions was much greater, amounting to 2½ ins. at the eastern end and to more than 8 ins. at the Canadian end.

An unusual opportunity for observing the effects of diversions was afforded in the latter part of July, 1908, by a two weeks' shut-down of the plant of the Niagara Falls Power Co. The effects produced by changes in the quantity of water diverted in the Grass Island-Chippawa pool were ascertained directly at that time, giving a check on previous deductions. We reprint below in abstract from the "Report of the Chief of Engineers, U. S. Army," for the year ending June 30, 1909, an account of the results of these observations.

Briefly summarized, the results of the operations of 1908 serve to prove that while the increase in diversion since 1898 in the Chippawa-Grass Island pool, amounting roughly to 7,000 cu. ft. per second, has produced no a[p]parent effect upon the level of Lake Erie, this is pr[o]ably due to the fact that the lowering has been comp[en]sated by the construction during the same period of t[he] diversion works of the Ontario Power Co. below Ch[i]pawa. In the absence of such compensation, the lower[ing] due to the increased diversion would have amounted less than ½ in. This conclusion is based upon the di[s]covered relation between the volume of the diversion Chippawa-Grass Island pool at the falls and the dischar[ge] of Lake Erie, which, as derived from the study of ga[ge] relations and of the measurements during the shut dow[n] shows that any change in the volume of this diversi[on] is accompanied by a change of about one-tenth t[he] amount in the flow at the International Bridge.

In addition, the observations prove that the effect [of] increased diversion in the above-named pool near t[he] falls, by the American power companies, is to reduce t[he] height of the crest of the American Falls by 0.02 ft. f[or] each 10,000 cu. ft. so diverted, and that the diversion [of] the full authorized amount—15,100 cu. ft. per second will lower this crest 0.03 ft., or about ⅜ in. Based [as] it is upon the extensive observations subsequent to July 1908, this determination serves to modify very materia[lly] the result stated in the annual report for 1908, p. 8[0], the latter being derived from a shut down of a few hou[rs] only, during which the change at the crest of the American Falls due to the shut down was coincident with a rise in Lake Erie due to a southwesterly storm.

While the lowering, due to the diversions of the American power companies, may not in itself be noticeable, it is increased to 0.053 ft. (= 0.64 in.) by the present diversion of the Ontario Power Co. The combined lowering tends to uncover shallow portions of the crest line of the American Falls. It is further accompanied by greater, and consequently more harmful, effects both in the American rapids and at the easterly or Terrapin Point end of the Horseshoe Falls. Terrapin Point is on the New York side of the boundary and, as depths there are naturally slight, the loss of 2.5 ins. in depth, which is the total due to all existing diversions, is a matter of moment in its relation to continuity of crest line.

But it is on the Canadian side of the boundary that the impairment of the falls is most serious. At the Canadian end of the Horseshoe Falls, which is known to be deficient in depth, the diversion of 15,100 cu. ft. per second produces a lowering of about 4.8 ins., which is increased to 8.44 ins. by the present diversions of the Ontario Power Co., the Electrical Development Co., the Canadian Niagara Power Co. and the International Railway Co., whose total diversion is now estimated at 10,950 cu. ft. per second. The losses at Terrapin Point and at the west end of the Horseshoe are relatively great and, as a whole, the falls have unquestionably been seriously injured by the diversions already made. Additional diversions, now under way, will add to the damage.

A full report upon the work under these allotments was submitted upon November 30, 1908, and reference is invited to this for detailed statements of ascertained gage relations and of the effects of diversion upon the rapids, upon the Horseshoe Falls, and upon the Niagara River.

Power Generated per Cubic Foot of Water Diverted.

As a result of the discharge measurements made in the intake canal of the Niagara Falls Power Co. in 1907 the officer then in charge of the supervision of the operations of the various power and transmission companies, under

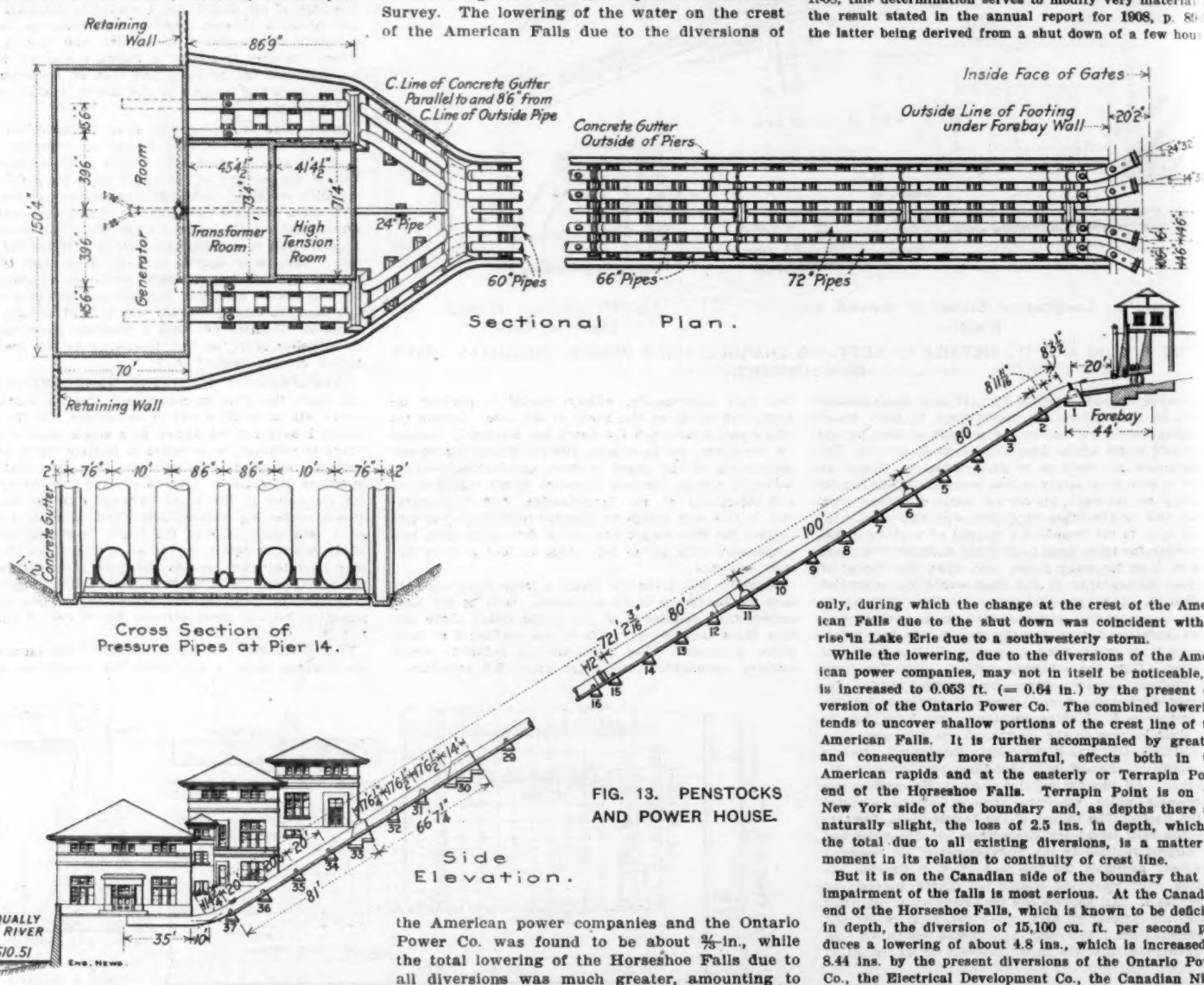


FIG. 13. PENSTOCKS AND POWER HOUSE.

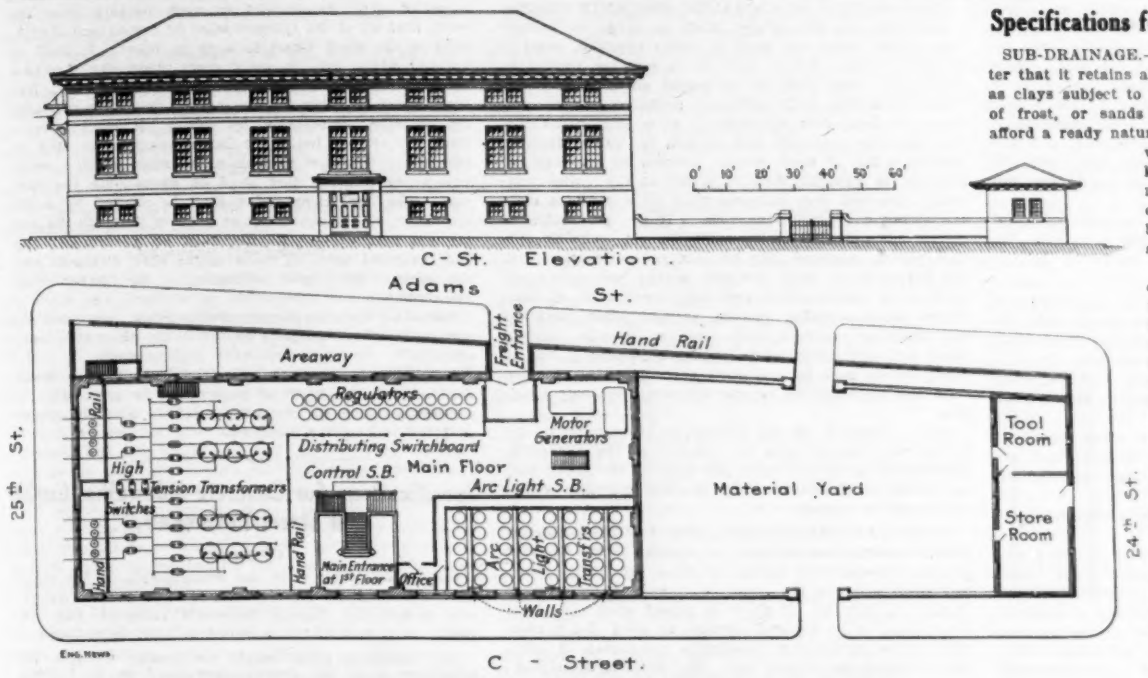


FIG. 14. TACOMA CITY SUBSTATION, MUNICIPAL POWER WORKS.

their permits issued by the Secretary of War, imposed upon this company a limitation to such diversion as might be necessary to generate not to exceed 65,000 E.HP., this limitation being derived from a consideration of the power-house load curves covering the time of the discharge measurements.

Comparison served to show that this company generated an electrical horsepower for each 0.123 cu. ft. of water diverted, and as the International Paper Co. diverted directly from the canal of the power company 700 cu. ft. per second there remained for the latter 7,900 cu. ft., corresponding roundly to 65,000 E.HP.

The validity of the conversion coefficient for forming switchboard readings into volume of water diverted, so far as it applies to conditions actually existing at the time of the discharge measurements, can not fairly be questioned, but as the two power-houses belonging to this company differ in the details of their construction, with claimed higher mechanical efficiency in the newer house, the officials of the company have asserted that under certain entirely practicable conditions of operation the value of the conversion coefficient will be found to be lower than the figures given.

An exhaustive series of tests was undertaken to check the Niagara Falls Power Co.'s claim of higher efficiency in the newer part of their plant. Final results are not yet given, but it is stated as already certain that this company, by restricting the number of generators in operation to 16, of which not more than six must be in the older power-house, can generate 75,000 HP. without exceeding a diversion of 8,600 cu. ft. per second.

INFORMATION ON THE DEPRECIATION OF water-works is sought by a committee of the American Water Works Association, headed by Mr. John W. Alvord, M. Am. Soc. C. E., Hartford Bldg., Chicago. It appears that the work of collecting information has been entrusted to Mr. James N. Hazlehurst, M. Am. Soc. C. E., Candler Bldg., Atlanta, Ga. A blank form has been prepared for use by those willing to give information. Facts regarding water-tanks and towers of various material, for different kinds of pipe, etc., are desired.

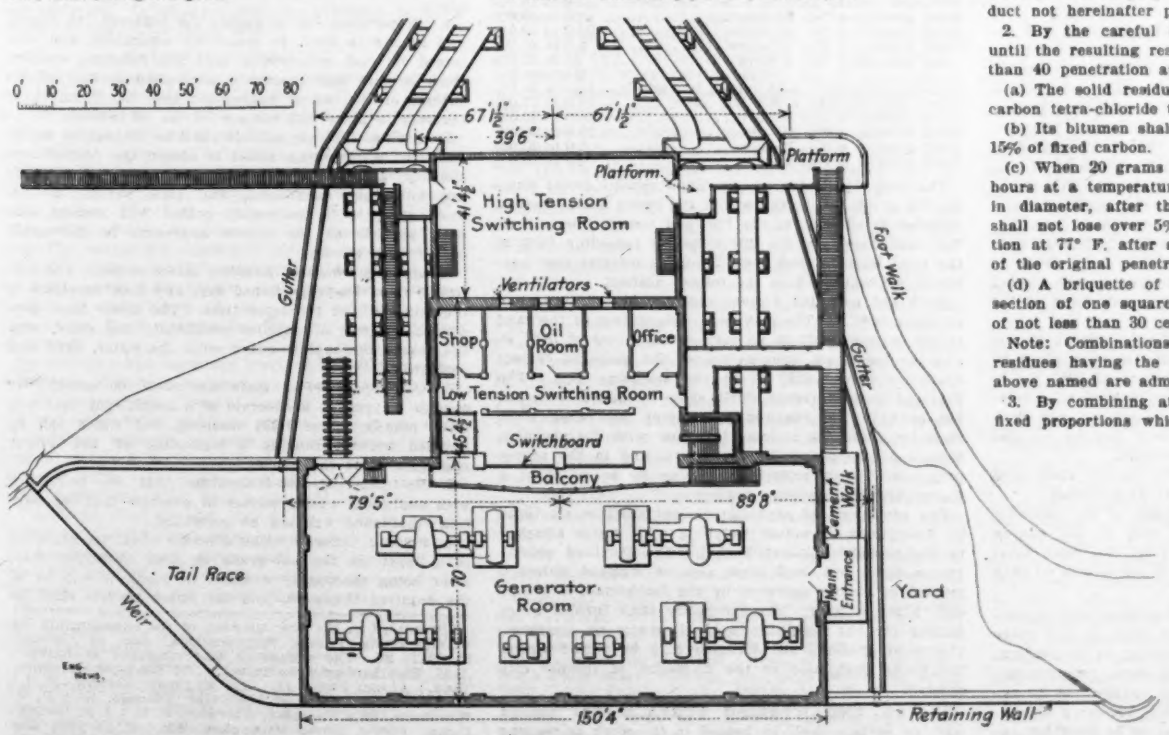


FIG. 15. PLAN OF POWER HOUSE, NISQUALLY RIVER DEVELOPMENT.

Specifications for Sheet Asphalt Pavement.*

SUB-DRAINAGE.—When the soil is of such a character that it retains an excessive amount of moisture, such as clays subject to swelling or heaving under the action of frost, or sands similar to quick sand that do not afford a ready natural drainage, subdrains should be provided. These may be of two general kinds: (1) Tile drains of open porous material, or vitrified tile laid with open joints; (2) trenches filled with broken stone, gravel, cinders or other similar material.

In some cases it may be sufficient to construct a sub-drain on each side of the roadway at or near the lines of the gutters, but when the soil is of a very wet nature, it may be advisable to lay additional lines of drains which may be in or near the middle of the roadway. This system of drains may be varied by diagonal lines of drains running from near the crown of the roadway to the gutters. In all cases the drains should have connections with the existing sewers, catch basins or inlets.

FOUNDATIONS.—After all necessary grading has been done to bring the surface to sub-grade, the street shall be thoroughly rolled with a steam roller weighing not less than ten tons. If settlement occur, the depression shall be filled and then rolled until the surface is solid and uniform. All filling shall be free from animal or vegetable matter and of a character approved by the engineer. Should the foundation be of sand, which would be impracticable to roll, the entire roadway from curb to curb shall be thoroughly puddled by flooding with water one or more times if found to be necessary. The contractor shall furnish all water and hose for puddling and all necessary labor to properly perform the work.

REFINED ASPHALT.—The refined asphalts to be used for paving mixtures herein required shall be derived in the following manner:

1. By heating, if requiring refinement, crude, natural, solid asphalt, to a temperature of not over 400° F. until all the water has been driven off. Crude, natural, solid asphalt shall be construed to mean any natural mineral bitumen either pure or mixed with foreign matter, from which, through natural causes in the process of time the light oils have been driven off until it has a consistency harder than 100 penetration at 77° F. At least 98½% of the contained bitumen in the refined asphalt which is soluble in cold carbon bisulphide, shall be soluble in cold carbon tetra-chloride. Such asphalt must melt readily upon the application of heat. In no case shall it be prepared at the refinery with any product not hereinafter provided for.

2. By the careful distillation of asphaltic petroleum until the resulting residue has a consistency not harder than 40 penetration at 77° F.

(a) The solid residue so obtained shall be soluble in carbon tetra-chloride to the extent of 98½%.

(b) Its bitumen shall yield upon ignition not more than 15% of fixed carbon.

(c) When 20 grams of the material are heated for five hours at a temperature of 325° F. in a tin box 2½ ins. in diameter, after the manner officially prescribed, it shall not lose over 5% by weight nor shall the penetration at 77° F. after such heating be less than one-half of the original penetration.

(d) A briquette of the solid residue having a cross-section of one square centimeter shall have a ductility of not less than 30 centimeters at 77° F.

Note: Combinations of asphaltic and semi-asphaltic residues having the ductility and other characteristics above named are admitted under Section 2.

3. By combining at the paving plant in uniform and fixed proportions which shall be satisfactory to (proper city official) solid, natural asphalt and solid asphaltic residue as hereinbefore described. The refined natural asphalt shall be derived from the crude natural asphalt of the quality and in the manner specified before, except that the crude natural asphalt may have added to it, if desired, at the refinery, as a partial fluxing, an amount of asphaltic or semi-asphaltic flux of the character and within the limit specified elsewhere herein, such

*Report of a Committee at the Chicago Meeting of the Organization for Standardizing Paving Specifications.

fluxing to be conducted under the supervision of (proper city official) when desired. In the use of these mixtures of refined asphalts or asphaltic cements, only asphaltic or semi-asphaltic fluxes shall be used, except in those cases where the solid natural asphalt is of such character that when mixed with paraffine flux without the further addition of any other material, it will produce an asphaltic cement complying with the requirements hereinafter set forth under that head. In such cases any of the fluxes elsewhere herein specified may be used.

The preparation and refining of all asphalts admitted under these specifications shall be subject to such inspection at the paving plants and refineries as the (proper city official) may direct.

FLUX.—The fluxing material may be a paraffine, a semi-asphaltic, or an asphaltic residue which shall be tested with and found suitable to the asphalt to be used. It shall be free from water or other impurities.

The residuums must have a penetration greater than 3½ centimeters, with a No. 2 needle at 77° F. under 50 grams weight for 1 sec.

A natural Maltha may be used if it passes the heat and flash tests specified under "a" (below) and all fluxes must futhermore remain soft after heating for five hours at 400° F.

All residuums shall be soluble in cold carbon tetrachloride to the extent of 99%.

(a) The paraffine residuum shall have a specific gravity of 0.92 to 0.94 at 77° F. It shall not flash below 350° F. when tested in the New York State closed oil tester, and shall not volatilize more than 5% of material when heated five hours at 325° F. in a tin box 2½ ins. in diameter as officially prescribed. The residue after heating shall flow at 77° F. and shall be homogeneous and shall show no coarse crystals.

(b) Semi-asphaltic residuum shall have the same general characteristics as paraffine residuum except that it shall have a specific gravity of .94 to .98 at 77° F.

(c) Asphaltic residuum shall have the same general characteristics as paraffine residuum except that the specific gravity shall be not less than .98 nor more than 1.04 at 77° F. The asphaltic residuum after evaporation at 500° F. to a solid of 50 penetration shall have a ductility of not less than 30 cm.

ASPHALTIC CEMENT.—The asphaltic cement prepared from materials above designated shall be made up from the refined asphalt or asphalts, and the flux where flux must be used, in such proportions as to produce an asphaltic cement of a suitable degree of penetration. The proportion of the refined asphalts comprising the cement shall in no case be less than 40% by weight.

When weight of flux in the asphaltic cement prepared from solid natural asphalts exceeds 25% thereof, asphaltic or semi-asphaltic flux shall be used. Semi-asphaltic flux in such case, must have a gravity of not less than .95 at 77° F.

Refined asphalts and flux comprising the asphaltic cement shall, when required, be weighed separately in the presence of the authorized inspectors or agents of [proper city officials].

Refined asphalt and flux used in preparing the cement shall be heated together in a kettle at temperatures ranging from 250° to not over 375° F., and be thoroughly agitated when hot by air, steam or mechanical appliances, until the resulting cement has become thoroughly mixed into a homogeneous mass. The agitation must be continued during the entire period of preparing the mixtures. Cement shall always be of uniform consistency, and if any portion should settle in the kettles between intervals of using the same, it must be thoroughly agitated before being drawn for use.

The asphaltic cement shall have a penetration of from 30 to 100 which shall be varied within these limits to adapt it to the particular asphalt used in the paving mixture and to the traffic and other conditions of the street.

(a) When 20 grams of the asphaltic cement of the penetration to be used in the paving mixture shall be heated for five hours at a temperature of 325° F., in an oven as officially specified, there must not be volatilized more than 5% of the bitumen present, nor shall the penetration at 77° F. after such heating be less than one-half of the original penetration.

(b) The bitumen of the asphaltic cement shall give upon ignition, not more than 15% of fixed carbon.

(c) A briquette of the pure bitumen of the asphaltic cement of the penetration to be used in the paving mixture, having a cross section of 1 sq. cm., shall elongate to the extent of not less than 10 cm. nor more than 100 cms. at 77° F.

SAND.—The sand shall be hard-grained and moderately sharp. It shall be free from loam or any other foreign material, and shall be so graded as to produce, in the finished surface mixture, the mesh requirements elsewhere herein specified. It shall contain not to exceed 6% of sand that will pass a No. 200-mesh sieve.

BINDER STONE.—Stone or gravel to be used for asphaltic concrete binder shall be hard and durable, free from all foreign substances, and of varying sizes, from 1 in. down.

PREPARATION OF ASPHALTIC CONCRETE BINDER.—Asphaltic concrete binder shall be made as follows: The binder stone and sand as above specified, shall be heated to from 200 to 325° F. in suitable appliances. Stone and sand shall be measured off separately and then be mixed, with sufficient asphaltic cement prepared as heretofore specified, in such proportions that the resulting aggregate will contain by weight material passing a No. 10 mesh screen, between 30 and 40% and bitumen in quantity from 5 to 8% of the entire mixture. Concrete thus prepared shall be a compact mass containing a minimum of voids. If the permission of [proper city officials] were available, old asphaltic surface paving mixtures may be used in combination with the binder stone, such mixtures having been previously crushed or disintegrated and augmented with at least 1% of fresh asphaltic cement, so that when combined the resulting concrete shall form an equally compact mass and correspond as to aggregate passing a No. 10 mesh screen and in contained percentages of bitumen with the requirements for the mixture previously specified.

Note.—Inasmuch as the percentage of bitumen in the binder will depend upon the grading of the aggregate, the proportions of the materials used in the above may be varied by [authorized city official], but only within the limits designated.

LAYING ASPHALTIC CONCRETE BINDER.—The asphaltic concrete binder shall be brought to the work in wagons, covered with canvas or other suitable material, and upon reaching the street shall have a temperature of 200° to 325° F. It shall be placed upon the street and raked to a uniform surface to such depth that, after being rolled and thoroughly compacted, it shall have a thickness of —— ins. The surface, after compression, shall show at no place an excess of asphaltic cement, and any spot covering an area of 1 sq. ft. or more showing an excess of asphaltic cement, shall be cut out and replaced with other material. Smaller spots may be dried by the use of stone, dust and smoothers. Any asphaltic concrete binder broken up during the process of laying must be removed and replaced with new material. Asphaltic concrete binder shall be followed and covered with wearing surface as soon as is practicable in order to effect the most thorough bond betwen the binder and the wearing course.

ASPHALTIC SURFACE MIXTURE OR WEARING COURSE.—The Committee in presenting two kinds of mixtures for wearing surface, one having as filler Portland cement and one with a stone dust filler, considers that the adoption or application of either would be a matter of local conditions and accordingly should be left to the discretion of the engineer in charge of such paving construction.

The surface mixture shall consist of asphaltic cement, Portland cement (stone dust) and sand proportioned by weight so that the resulting mixture will contain average proportions of the whole mixture as follows:

	Mixture A.
Bitumen soluble in cold carbon bisulphide..	11.0 to 13.5%
Portland cement passing a No. 200 sieve...	10.0 to 15.0%
Sand passing a No. 80 sieve.....	18.0 to 36.0%
Sand passing a No. 40 sieve.....	20.0 to 50.0%
Sand passing a No. 10 sieve.....	8.0 to 20.0%
Sand passing a No. 4 sieve.....	up to 10.0%
	Mixture B.
Bitumen soluble in cold carbon bisulphide..	10.5 to 13.5%
Stone dust passing a No. 200 sieve.....	10.0 to 15.0%
Sand passing a No. 80 sieve.....	18.0 to 36.0%
Sand passing a No. 40 sieve.....	20.0 to 50.0%
Sand passing a No. 10 sieve.....	8.0 to 20.0%
Sand passing a No. 4 sieve.....	up to 10.0%

The item designated as "Portland cement (stone dust) passing a No. 200 sieve" within the limits named herein, includes in addition to the Portland cement (stone dust) fine sand passing a No. 200 sieve not exceeding 4½% of the total mixture, and such 200-mesh mineral dust naturally self-contained in the refined asphalt.

Sand and asphaltic cement shall be heated separately to about 300° F. The maximum temperature of the sand at the mixers shall in no case be in excess of 375° F. and the maximum temperature of the asphaltic cement shall not exceed 325° F. at the discharge pipe. The Portland cement (stone dust) shall be mixed with the hot sand in the required proportions, and then these shall be mixed for at least 1 minute with the asphaltic cement at the required temperature, and in the proper proportions in a suitable apparatus so as to effect a thoroughly homogeneous mixture.

The proportion of asphaltic cement shall at all times be determined by actual weighing with scales attached to the asphaltic cement bucket. The Portland cement (stone dust) and sand must also be weighed unless a method of gaging approved by the (authorized city official) shall be used. The contractor shall furnish every facility for the verifications of all scales or measures. The sand gradings and bitumen may be varied within the limits designated in the discretion of (proper city official).

LAYING THE WEARING SURFACE.—The asphalt wearing surface shall be hauled to the work in wagons provided with a canvas or other suitable cover. It shall leave the plant at a temperature between 250° and 325° F., as suitable for the asphalt used. Upon arrival at the street it shall be dumped at such distance from the work that all of the mixture must be turned and distributed to the place where it is to be raked. It shall be spread, while hot, to such depth upon the asphaltic concrete binder, which must be thoroughly dry, free from leaves or other foreign matter, that after receiving its ultimate compression by rolling, it shall have a thickness of —— ins. The initial compression may be effected by means of a small roller, after which a small amount of mineral dust shall be swept over the surface. The final compression shall be effected by a 10-ton roller, or the equivalent of not less than 250 lbs. per running inch width. Rolling must be steadily kept up and continued until all roller marks shall disappear and the surface shall give indication of no further compressibility.

Note.—All tests herein provided must be conducted according to official methods on file in the office of (proper official).

All penetrations indicated herein unless otherwise specified refer to the depth of penetration in hundredths of centimeters of a No. 2 needle weighted with 100 grams at 77° F. acting for 5 seconds.

Specifications for Concrete Sidewalks, Curbs and Street Pavements.*

Cement.

The cement shall meet the requirements of the standard specifications for Portland cement of the American Society for Testing Materials (adopted Aug. 16, 1909), with Section 21, amended to read as follows:

The minimum requirements for tensile strength for briquettes 1 sq. in. cross-section shall be as follows, and the cement shall show no retrogression in strength within the periods specified:

	Strength—lbs. per. sq. in. Neat.	1 to 3.
24 hours in moist air.....	175	...
7 days (1 in moist air, 6 in water)..	500	...
28 days (1 in moist air, 27 in water).	600	...

Provided, however, if the cement fails to meet the requirements of the 24-hour neat test, it may, at the discretion of the engineer, be held for further tests before being rejected, with the mixture of 1 cement to 3 standard Ottawa sand, in no case shall the increase in strength at 28 days be less than 20% over the strength shown at seven days.

Concrete for Pavement Foundations.

1. Cement.—(As specified above.)

2. Fine Aggregate.—The fine aggregate shall consist of any material of siliceous, granitic or igneous origin, free from mica in excess of 5%, and other impurities, uniformly graded, the particles ranging in size from ¼-in. to that which will pass a No. 100 standard sieve.

3. Coarse Aggregate.—The coarse aggregate shall be sound gravel, broken stone or slag, having a specific gravity of not less than 2.6. It shall be free from all foreign matter, uniformly graded, and shall range in size from ¼-in. up, the largest particles not to exceed in any dimension half the thickness of the concrete in place.

4. Proportions.—In preparing the concrete, the cement and aggregate shall be measured separately, and then mixed in such proportions that the resulting concrete shall contain fine aggregate amounting to half of the volume of the coarse aggregate; and that 7 cu. ft. of concrete in place will contain 94 lbs. of cement.

5. Mixing.—The ingredients shall be thoroughly mixed, sufficient water being added to obtain the desired consistency, and the mixing continued until the materials are uniformly distributed, and each particle of the fine aggregate is thoroughly coated with cement, and each particle of the coarse aggregate is thoroughly coated with mortar.

Where a mechanical concrete mixer is used, the materials must be proportioned dry, and then deposited in the mixer all at the same time. The mixer must produce a concrete of uniform consistency and color, with the stones thoroughly mixed with the water, sand and cement.

6. Consistency.—The materials shall be mixed wet enough to produce a concrete of a consistency that will flush readily under light tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.

7. Re-tempering.—Re-tempering, that is, re-mixing with additional water, mortar or concrete that has partially hardened will not be permitted.

8. Placing Concrete.—The concrete shall be deposited in a layer on the sub-grade in such quantities that, after being thoroughly rammed in place, it will be of the required thickness, and the upper surface shall be

*Presented at the first meeting of the Organization for Standardizing Paving Specifications, held at Chicago, Feb. 21, 26. The committee was composed as follows: J. H. Weatherford (chairman), City Engineer, Memphis, Tenn.; Abram Swan, Jr. City Engineer, Trenton, N. J.; N. E. Murray, Supt. of Sidewalks, Chicago, Ill.; D. C. Washburn, City Engineer, Aberdeen, S. D.; J. A. Jansen, Comm. Public Works Milwaukee, Wis.; C. D. Hill, Engineer of Bd. Local Impts., Chicago, Ill.; Otto H. Klein, Chief Engineer, New York, N. Y.; Mont Schuyler, Engr. City Testing Laboratory, St. Louis, Mo.; W. W. Reed, City Engineer, Green Bay, Wis.

true, uniform and parallel with the surface of the finished pavement.

In conveying the concrete from the place of mixing to the place of deposit, the operation must be conducted in such a manner that no mortar will be lost and the concrete must be so handled that the foundation will be of uniform composition throughout, showing no excess nor lack of mortar in any place.

9. Protection.—When complete the foundation shall be kept moist for four days and it shall be protected from traffic until the concrete has thoroughly set before the wearing surface is put on.

Concrete Pavement.

Because of lack of experience with this form of pavement, we hesitate to recommend the adoption of specifications. This subject should be given further study. There are two or more concrete pavements now in use, on which patents have been obtained. We consider it outside of the jurisdiction of the committee to pass upon the merits of these pavements. If any municipality should desire to lay any of these patented pavements, specifications should be obtained from the patentee, but the materials used in the work should conform to the requirements of the standard specifications

We believe that there are conditions where traffic is light, and economy and cost are essential considerations, where a concrete pavement may be used to advantage. In such cases we recommend for your consideration the following specifications:

[These specifications for concrete pavement are identical with the foregoing specifications for concrete foundation, with exceptions as follows:

(A). The coarse aggregate is to be "sand broken stone trap rock, or granite having a specific gravity not less than 2.6," etc.

(B) The proportions to be such that 5 cu. ft. of concrete (instead of 7 cu. ft.), will contain 94 lbs. of cement.

There are also the following additional paragraphs. Ed.]

9. Finishing.—The pavement shall be finished by thorough hand-tamping until the mortar flushes freely to the surface, then lightly tamped with a templet made of 2-in. plank shaped to conform to the curvature of the surface of the finished pavement and having a length of not less than half the width of the roadway to give a uniform surface, with the slight markings thus made transverse to the street.

10. Expansion Joints.—Expansion joints shall be placed at right angles to the curb line at intervals of 50 ft. These joints shall be not less than 1-in. wide and shall be filled with creosoted soft wood timber with the grain vertical and extending full depth of the pavement.

11. Protection to Work.—During the first four days after placing, the pavement shall be kept moist and it shall be protected against traffic until the concrete has thoroughly set. In no event shall the pavement be used within ten days after being laid.

Concrete Sidewalk.*

Coarse Aggregate.—The coarse aggregate shall be sound gravel, broken stone or slag having a specific gravity of not less than 2.6. It shall be free from all foreign matter, uniformly graded and of sizes that will pass a 1-in. screen and be retained on a ¼-in. screen.

Water.—The water used in mixing the concrete shall be clean, free from oil, acid, strong alkalis or vegetable matter.

Base Proportions.—In preparing the concrete for the base, the cement and aggregate shall be measured separately, and then mixed in such proportions that the resulting concrete shall contain fine aggregate amounting to half of the volume of the coarse aggregate; and that 5½ cu. ft. of concrete in place will contain 94 lbs. of cement.

Consistency.—The materials shall be mixed to produce a concrete of such consistency that the water will flush to the surface under heavy tamping.

Forms.—The forms shall be smooth, free from warp, of sufficient strength to resist springing out of shape, and of a depth to conform to the thickness of the proposed walk. All mortar and dirt shall be removed from forms that have been previously used.

The forms shall be well staked and set to the established lines, their upper edges conforming to the grade of the finished walk, which shall have sufficient fall from the lot line towards the curb line to provide for drainage, but shall not exceed ⅝-in. per ft.

The base shall be blocked out in sections, which shall not measure more than 6 ft. in any dimension.

The cross forms shall be of ¼-in. metal, of a depth to correspond to the thickness of the proposed walk, and shall extend full width of the walk and be set at right angles to the side forms. They shall be left in place until the wearing surface is floated.

*These are identical with the specifications for concrete foundation, except for the paragraphs given herewith.

Wearing Surface.—The wearing surface shall be composed of 1 part Portland cement and 2 parts fine aggregate, mixed with sufficent water to produce a mortar of a consistency which will not require tamping and which can be easily spread into position with a straight edge. The mortar shall be mixed in a mortar box and spread on the base immediately after mixing. In no case shall the wearing surface be placed after the base has set.

After the wearing surface has been worked to an approximately true plane, the slab marking shall be made directly over the joint in the base. Such marking shall be made with a tool which will cut entirely through and completely separate the surface of adjacent slabs.

Edges.—The slabs shall be rounded on all surface edges to a radius of about ½-in.

Troweling.—The surface shall be troweled smooth. The application of neat cement to the surface in order to hasten hardening is prohibited.

Protection.—When completed the walk shall be kept moist and protected from traffic and the elements for at least three days.

CONCRETE CURB AND GUTTER.—These specifications are practically identical with those for concrete walks, except as to the five aggregate and the requirement that the work must be kept moist for 4 days and protected for at least 10 days. The two exceptional paragraphs are as follows:

Fine Aggregate.—The fine aggregate shall consist of any material of siliceous granitic or igneous origin, free from mica in excess of 5%, and other impurities, and shall be graded sizes ranging from ⅛-in. down to that which will be retained on a No. 80 standard sieve for the top or wearing surface; and from ¼-in. down to that which will pass a No. 100 standard sieve for the base.

Curb and Gutter Not Built in Place.—Where built at a point removed from the work, they shall be constructed in the same manner and of the same materials as above specified and shall be allowed to harden for at least ten days before being transported to their position in the work. The length of any section shall be not less than 4 ft. nor more than 6 ft.

Specifications for Bituminous Concrete Paving.*

(In the specifications for bituminous concrete the committee does not assume to pass on the validity of patents that may have been issued for certain paving mixtures and methods, and the various municipalities that may adopt these specifications are advised to determine their own policies as to the recognition of these patents.)

Foundation.—The foundation upon which the pavement is laid may be either concrete or macadam.

Concrete Foundation.—This may be laid according to the standard specifications for concrete foundation, the surface being made rough and grainy so the paving material may get a proper bond or grip on the concrete.

New Macadam Foundation.—If the pavement is to be laid on a new macadam foundation the macadam shall be built according to the standard specifications except that the upper ½-in. shall not be completely filled and bonded, the intention being (as with the concrete foundation) to produce a somewhat rough, grainy surface into which some of the paving mixture will be forced by the roller. For heavy traffic, 8 ins. of well compacted macadam may be considered equal to 6 ins. of concrete; and for light or ordinary traffic 6 ins. of macadam equal to 4 or 5 ins. of concrete.

Old Macadam Foundation.—If the pavement is to be laid on an old macadam base, the surface shall be thoroughly swept and cleaned of all fine material that may be either caked upon the surface of the stone or lying loose as dust, thereby exposing the clean stone in the surface for the reception of the paving material. If the old macadam is not in suitable condition or proper grade after cleaning it shall be spiked up and redressed to the proper crown and grade, the coarse stone being left at the top, or new stone added when, in the opinion of the engineer, it is needed to give the desired grainy surface or thickness of foundation.

It shall then be thoroughly rolled with the use of as little water as possible so the macadam does not finish smooth.

When it is not practicable to secure a foundation, either macadam or concrete, with sufficient grain in the surface to give the desired bond or key between the foundation and the paving material, the adhesion between the two may be increased by sprinkling the foundation with the bituminous cement before the paving mixture is spread, using not exceeding ¼ gal. per sq. yd.

Old Brick or Granite Foundation.—An old brick or granite block pavement, if in the opinion of the engineer it is well supported and stable, may be used as a base by thoroughly cleaning the old pavement and sprinkling its surface with the bituminous cement.

Wearing Surface.—On the foundation as specified shall be laid the bituminous concrete wearing surface, which shall be composed of carefully selected, sound, hard, crushed stone and sand mixed with bituminous cement and laid as hereinafter specified. This wearing surface shall have a thickness of — ins. after thorough compression with a 5-ton tandem roller.

Mineral Aggregate.—The mineral aggregate shall consist of broken stone or broken stone and sand of a fairly uniform grading from the largest to the smallest particles in such proportions as to give the mixture a maximum degree of density and low percentage of voids. The maximum size of stone used may range from that passing a screen having circular openings from ¾-in. to 1¼ ins. diameter. Crusher run of stone between 1-in. and screenings passing ¼-in. may be used if found to be fairly evenly graded. Coarser stone when used shall be graded and remixed in proper proportion. (The screenings passing the ¼-in. mesh screen may be used when the bitumen is refined coal tar or an asphalt not having a low ductility.) Coarse and fine sand having proper grading shall be added in such proportions as necessary to secure the dense aggregate specified above. Stone dust or hydraulic cement may be added as needed when the character of the bitumen used requires it.

Bituminous Cement.—The bituminous cement may be either refined coal tar or asphaltic cement.

Coal Tar.—The coal tar must be the residue of the distillation of coal tar only and be specially refined for the purpose. No admixture of hard pitch with the lighter oils of coal tar will be permitted. The cement shall conform to such physical and chemical tests necessary to satisfy the (local officials) as to its suitability.

(The Committee does not find available sufficient data enabling the preparation of more detailed specifications at this time. It recommends careful experiments and collection of data for future consideration.)

Asphaltic Cement.—The asphaltic cement may be prepared: (1) from refined natural asphalt; (2) from the residue obtained in the oxidation or distillation of asphaltic or semi-asphaltic petroleum; (3) from any uniform combination of the preceding materials together with a suitable flux, if flux be necessary, such combination being subject to the approval of the engineer.

Each bidder must state the nature and origin of the bitumen to be used by him, and further shall submit samples of the bitumen with his proposal. The asphaltic cement shall pass the requirements designated below.

(1) It shall have a penetration of 0.30 to 0.100 centimeter at 77° F., Dow standard, which shall be suitable to the nature of the material used and to the traffic and other conditions of the street.

(2) When 20 grams of the cement are maintained at a temperature of 325° F. for five hours in a tin box 2½ ins. diameter, there must not be volatilization more than 3% by weight of the bitumen present, nor shall the original penetration be reduced thereby over one-half.

(3) The bitumen of the asphaltic cement shall give upon ignition not more than 15% of fixed carbon.

(4) Of the bitumen of the asphaltic cement which is soluble in carbon disulphide, 98½% shall be soluble in carbon tetra chloride.

(5) At 32° F. the bitumen of the cement shall have a penetration of not less than 10 when tested one minute with the needle weighted to 200 grams, and at 115° F. when weighted to 50 grams for five seconds, shall have a penetration of not more than 280.

(6) The cement shall not flash at a less temperature than 350° F. New York State closed oil tester.

Method of Mixing.—The aggregate shall be thoroughly dried in properly designed driers before mixing with the bitumen. The driers shall be of the revolving type, thoroughly agitating and turning the materials during the process of drying. When the aggregate is thoroughly dried and heated to a temperature of from 200 to 350° F., depending on the bituminous cement used, it shall be immediately, before cooling or exposing to moisture, mixed with the hot bituminous cement as hereinafter specified.

The bituminous cement shall be melted in a tank arranged so the heat can be properly and easily controlled and regulated. When melted and raised to a temperature of from 200 to 350° F., depending on the bituminous cement used, it shall be combined in proper proportions with the hot aggregate and immediately mixed in a properly designed mixer with revolving blades until a thorough and intimate mixture of the ingredients has been accomplished, and the particles composing the ag-

*Presented by the Committee on Asphalt and Bituminous Pavements at the first meeting of the Organization for Standardizing Paving Specifications. The committee was composed as follows: Geo. W. Craig (Chairman), City Engineer, Omaha, Neb.; Linn White, Chief Engr., South Park Board, Chicago, Ill.; Geo. W. Tonson, Chief Engr. Dept. Public Works, Toledo, O.; W. R. Benson, Chief Bureau of Highways, Philadelphia, Pa.; J. M. Burrows, Asst. City Engineer, Des Moines, Ia.; G. E. P. Babcock, First Asst. Engineer, Buffalo, N. Y.; L. W. Rundlett, Comr. of Public Works, St. Paul, Minn.; L. Kirschbraun, Asphalt Chemist, Chicago; Geo. F. McGonagle, City Engineer, Salt Lake City, Utah; L. W. Anderson, City Engineer, Grand Rapids, Mich.

gregate evenly and thoroughly coated with the bituminous cement. The mixer shall not be exposed directly to the action of the fire.

Laying.—While still hot from the mixer, the paving mixture shall be spread evenly on the foundation with hot iron rakes or shovels or both, so that when compressed with the roller it shall have the thickness specified above, with the surface even and true to grade. Along the curb and around manholes, catch basins and other obstructions in the street where the roller cannot reach, the compression shall be secured by the use of hot iron tampers. The tamping shall be done as quickly as possible after the material is spread, while still hot and pliable. When the paving mixture is hauled on the street in dump wagons it shall be kept covered with canvas to retain heat, dumped on platforms and shoveled into place and raked to secure the proper grade. As soon as the temperature will permit, the paving mixture shall be rolled with a tandem steam roller weighing at least five tons and the rolling continued, working lengthwise and diagonally of the street. Rolling must be steadily kept up and continued until all roller marks shall disappear, and the surface gives indication of no further compressibility.

The paving shall be done continuously, so the number of joints between the hot and cold material shall be reduced to the minimum. When it is not practicable to lay it continuously and a joint is unavoidable the edge of the cold material shall be trimmed down to a rough feather edge, and the surface, where the joint is to be made, painted over with bituminous cement, the hot material raked over the feathered edge and thoroughly rolled. Instead of trimming the cold material joint strips may be used consisting of strips of canvas about 18 ins. wide with three parallel lines of ¾-in. ropes sewed on the underside about 3 ins. apart. The joint strips shall be laid on the feather edge of the freshly raked material with the upper rope at the line where the thickness begins to decrease and the rolling completed on top of the canvas as for finished pavement. The faces of the curb and gutter, iron castings, etc., shall be painted with the bituminous cement before the paving mixture is laid.

Surface Finish.—As soon as possible after the rolling of the mixture is finished, and while the surface is still fresh and clean, and if possible while warm, a skin coat of bituminous cement of proper consistency to be flexible when cold shall be spread over the surface. It shall be spread on while at a temperature of from 200° to 350° F., depending on the bituminous cement used, and evenly spread with rubber squeegees. Only a sufficient coat shall be spread to flush the surface voids without leaving an excess. Immediately over this a top dressing of torpedo sand, fine gravel or stone chips free from dust, which must be thoroughly dry and heated in cold weather, shall be spread and thoroughly rolled into the surface. A small surplus shall be left to be worn in or worn away by the traffic.

After the sand or stone chips have worn in to the surface the street shall be swept, all excess of surfacing material removed and the street left clean.

Shrinkage and Forced Fits and the Stresses They Produce.

By A. LEWIS JENKINS.*

It is not uncommon in machine construction to employ shrinkage or forced fits for strengthening certain parts and for connecting such parts as a wheel to an axle, a crank-disk to a shaft, a tire to a wheel and numerous other machine elements requiring a connection that is rigid and reliable. It is the object of this paper to investigate the stresses produced by forced and shrinkage fits with allowances such as are commonly used in practice.

For shrinkage fits, the shaft is finished larger than the hole in the ring into which it is to enter. The hole having been enlarged by heating the surrounding metal to redness, the outer piece is placed in position on the shaft, and upon cooling contracts and grips the shaft. A piece of wrought iron 1 in. long will increase in length 0.00000656-in., and cast iron 0.00000618-in. for each degree Fahrenheit the temperature is raised. If a cast-iron ring be heated from ordinary temperature to redness (about 600° F.), the diameter will increase about 0.004-in. per inch of diameter. That is to say, a cold ring bored to 10 ins. in diameter will be enlarged to 10.04 ins. in diameter when heated to redness. For forced fits, the parts may be finished the same as for shrinkage fits but, instead of being heated, the ring is lubricated with linseed oil and forced on the shaft by the action of a hydraulic press or driven in place with sledges. For certain kinds of work, it is common practice to use two diameters or a taper in making forced fits, as this permits easy starting and lessens the chance of abrasion: but fits so made are less dependable than those having surfaces that are truly cylindrical. For diameters less than 10 ins., forced fits are more easily made than shrinkage fits, but they are not as reliable.

Much has been written concerning the allowances for fits between steel shafts and cast-iron

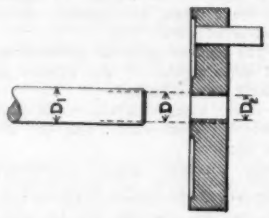


Fig. 1. Sketch Indicating Relations Between Initial and Final Diameters of Crank-Disk and Shaft for Shrinkage or Forced Fit.

rings and much valuable data is available. The allowances for different fits as given by Mr. Stanley H. Moore (Trans. Am. Soc. M. E., Vol. XXIV.) are as follows:

For shrinkage fits, $$d = \frac{\frac{17}{16} D + .5}{1000}$$

For forced fits, $$d = \frac{2D + .5}{1000}$$

For driven fits, $$d = \frac{\frac{1}{2} D + .5}{1000}$$

In which d denotes the allowance, or the amount the diameter of the shaft exceeds the diameter of the hole in the ring, and D denotes the nominal diameter of the shaft. The values obtained from the above formulas for forced fits are about twice as large as those frequently used in practice.

Investigation of Stresses Produced by Pressure Between Shaft and Ring.

To investigate the stresses produced by varying the allowance and proportions of the pieces fitted, suppose a crank-disk is bored D_2 inches in diameter and forced on a shaft D_1 inches in diameter, as shown in Fig. 1. The diameter of the bore will be increased and the diameter of the shaft decreased until they have the same value D. The enlarging of the hole produces a tensile stress in the disk, whereas the contracted shaft is subjected to a compressive stress.

If a thin cylindrical ring, having an inside diameter equal to that of the disk, be forced on the same shaft, it is reasonable to suppose that the stress in the shaft due to the ring will be less than that due to the disk, and the stress in the ring greater than the stress in the disk. If the ring were very thin, the value of D would be practically equal to the original diameter D_1 of the shaft, whereas the value of D for the disk would be less than D_1. Hence, it is seen that the stresses produced depend upon the proportions of the pieces fitted and the final diameter D after the fit is made. The value of D depends upon the relative proportions of the pieces and the elastic properties of the materials.

The pressure produced between the shaft and the ring is uniformly distributed over the surface of the fit, and acts radially, producing the same stress in the ring as would be produced by hydraulic pressure acting against its inner surface. The stresses in the shaft are the same as would be produced by subjecting it to external pressure by means of a liquid. If the ring be thin, the principal stress produced by the pressure is the hoop stress, or tangential tension, and may be considered as being uniformly distributed over the cross-sectional area of the ring.

In the subsequent discussion of the stresses produced by fits, the following notation will be used:

d = allowance per each inch of diameter, $\frac{D_1 - D_2}{D_2}$;
b = breadth of ring or length of fit in inches;
D_1 = diameter of shaft in inches before fitting;
D_2 = diameter of ring in inches before fitting;
D = diameter of ring and shaft in inches after fitting;
E_1 = modulus of elasticity of the shaft;
E_2 = modulus of elasticity of the ring;
F = force in pounds required to force the ring on the shaft;
P = total radial pressure in pounds between the surfaces;
p = pressure in pounds per square inch acting on the inner surface of ring;
p' = pressure in pounds per square inch acting on the outer surface of ring;
q = unit shearing stress in pounds per square inch in a shaft subjected to torsion;
r = inner radius of the ring in inches;
R = outer radius of the ring in inches;
S_h = hoop stress in pounds per square inch;
S_r = radial stress in pounds per square inch;
S_1 = equivalent hoop stress in the shaft, i. e., the linear stress that would produce a deformation equal to that actually produced by the combined stresses, S_r and S_h;
S_2 = equivalent hoop stress in the ring;
t = thickness of ring in inches;
T = total tensile stress in the ring in pounds;
μ = coefficient of friction;
λ = Poisson's ratio of lateral contraction.

THIN RINGS.—For a thin ring shrunk or forced on a shaft, it may be assumed that the latter does not deform, in which case $D = D_1$. The circumferential lengths of the ring before and after fitting may be taken as πD_2 and πD, the total elongation being $\pi (D - D_2)$ and the unit elongation $\frac{D - D_2}{D_2}$. Hence, since

$$\frac{\text{unit stress}}{\text{unit elongation}} = \text{modulus of elasticity, therefore}$$

$$S_h = E_2 \frac{D - D_2}{D_2}, \text{ and } T = S_h b t = b t E_2 \frac{D - D_2}{D_2} \quad (1)$$

The vertical components of the unit internal pressure p, acting radially on the inner surface of the ring as shown in Fig. 2, tend to separate the ring and produce a tensile stress T, at points A and B. To determine the value of this stress T, imagine a semicircular ring as shown in Fig. 3 being subjected to an internal pressure p. The sum of the downward forces is equal to $p\,b\,D$; and since the sum of the downward forces must equal the sum of the upward forces, or vertical components of p, the force tending to separate the ring at A and B is equal to $p\,b\,D$. By equating the internal resistance with the external forces,

$$p\,b\,D = 2\,T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

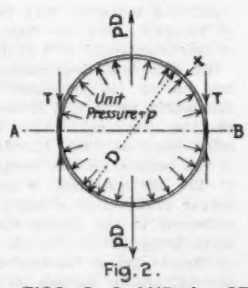


Fig. 2.

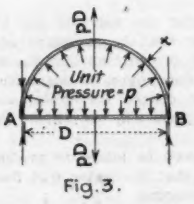


Fig. 3.

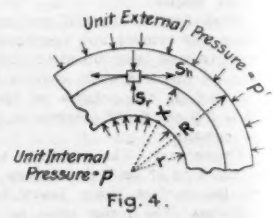


Fig. 4.

FIGS. 2, 3 AND 4. STRESS DIAGRAMS FOR THIN AND THICK RINGS SUBJECTED TO INTERNAL PRESSURE AS IN SHRINKAGE AND FORCED FITS.

By substituting the value of T given by equation (1), the normal pressure between the surfaces is:

$$p = \frac{2T}{bD} = \frac{2btE_2}{bD} \cdot \frac{D - D_2}{D_2} = \frac{2tE_2}{D} \cdot \frac{D - D_2}{D_2} \quad (3)$$

and the hoop stress in the ring is

$$S_h = \frac{PD}{2t} \quad (4)$$

THICK RINGS.—For rings that have to be thick, as in the case of bosses of wheels and

*Assistant Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio.

crank-disks, etc., the preceding formulas do not apply. The pressure p, acting on the inner surface of a thick ring, or a pressure p' acting on the outer surface of a shaft, produce at each point in the material two stresses at right angles to each other and to the axis. The principal stress in the ring is the hoop stress S_h, which tends to produce longitudinal rupture and the other is the radial stress S_r acting radially as shown in Fig. 4.

It is generally conceded that the hoop stress in the ring is greatest at the inner surface and diminishes according to some law from there to the outer surface. This law of variation has been expressed differently by various formulas, which are the result of different theories. The most modern conception of this stress variation has been expressed by Lamé as follows:*

In Fig. 4 the hoop stress at any point in the annulus at a distance X from the center is

$$S_h = \frac{r^2 p - R^2 p'}{R^2 - r^2} + \frac{r^2 R^2}{R^2 - r^2} \cdot \frac{p - p'}{X^2} \qquad (5)$$

The radial stress at X distance from the center is,

$$S_r = \frac{r^2 p - R^2 p'}{R^2 - r^2} - \frac{r^2 R^2}{R^2 - r^2} \cdot \frac{p - p'}{X^2} \qquad (6)$$

These equations are equally true for both internal and external pressure.

In Fig. 1 the diameter D_2 of the hole increases to D and the diameter D_1 of the shaft decreases to D when the ring is forced on the shaft. This change in diameters produces stresses in both the ring and shaft. The stresses in the ring are the hoop stress S_{h_2}, which is tensile, and the radial stress S_{r_2}, which is compressive. It is easily seen that these stresses assist each other in causing a tangential extension on the fibers. It has been found by experiment that when a bar is subjected to tension or compression its transverse dimensions are changed as well as the length, and the ratio of the transverse change to the change in length is called Poisson's ratio of lateral contraction, and is here denoted by λ.

The stress S_{h_2} causes a unit elongation equal to $\frac{S_{h_2}}{E_2}$ in the direction of the tangent; and S_{r_2} causes a deformation in the direction of the radius equal to $\frac{S_{r_2}}{E_2}$, and a deformation in the direction of the tangent equal to $\frac{\lambda_2 S_{r_2}}{E_2}$. Hence the unit elongation of the inner surface of the ring in the direction of the tangent, due to the stresses S_{h_2} and S_{r_2} is

$$\frac{S_{h_2}}{E_2} + \frac{\lambda_2 S_{r_2}}{E_2} = \frac{1}{E_2}(S_{h_2} + \lambda_2 S r_2)$$

and the equivalent hoop stress, i. e., the stress capable of alone producing this elongation in the ring, is,

$$S_2 = S_{h_2} + \lambda_2 S_{r_2}.$$

Both stresses in the shaft are compressive, hence the unit deformation of the shaft due to S_{h_1} and S_{r_1} in the direction of the tangent is

$$\frac{S_{h_1}}{E_1} - \frac{S_{r_1}\lambda_1}{E_1} = \frac{1}{E_1}(S_{h_1} - \lambda_1 S r_1)$$

and the equivalent stress in the shaft is

$$S_1 = S_{h_1} - \lambda_1 S_{r_1}.$$

STRESSES IN A THICK RING OR DISK.—The ring under consideration is subjected only to internal pressure, in which case, $p' = 0$ and the values of S_h and S_r increase as X decreases; hence for maximum values, $X = r$. By substituting these values in equations (5) and (6) the stresses at the inner surface of the ring are found to be

$$S_h = p\frac{R^2 + r^2}{R^2 - r^2} \qquad (7)$$

$$S_r = -p \qquad (8)$$

*The derivation of these formulas may be found in text books on the strength of materials.

By substituting the values $p' = 0$ and $X = R$ the stresses at the outer surface are found to be

$$S_h = \frac{2r^2 p}{R^2 - r^2} \qquad (9)$$

$$S r = 0 \qquad (10)$$

The equivalent hoop stress at the inner surface is

$$S_2 = S_{h_2} + \lambda_2 S r_2 \qquad (11)$$

and by substituting the values of S_h and S_r given by equations (7) and (8)

$$S_2 = p K + p\lambda_2 \qquad (12)$$

where $$K = \frac{R^2 + r^2}{R^2 - r^2} = \frac{\left(1 + \frac{t}{r}\right)^2 + 1}{\left(1 + \frac{t}{r}\right)^2 - 1}$$

STRESSES IN A HOLLOW SHAFT.—The hoop and radial stresses at the inner surface of a hollow shaft are found by making $p = 0$ and $X = r$ in equations (5) and (6), which gives

$$S_h = \frac{-2R^2 p'}{R^2 - r^2} \qquad (13)$$

$$S_r = 0 \qquad (14)$$

The negative sign means that the stress is compressive. It is to be remembered that the external pressure on the shaft is the same as the internal pressure on the ring, i. e., p' in the shaft formulas denotes the same pressure as p in the ring formulas.

The stresses at the outer surface of a hollow shaft are similarly found by making $p = 0$ and $X = R$, to be

$$S_h = -p' \frac{R^2 + r^2}{R^2 - r^2} \qquad (15)$$

$$S_r = -p' \qquad (16)$$

The hoop stress at both inner and outer surface is compressive, but since $2R^2$ is greater than $R^2 + r^2$, the hoop stress is greater at the inner surface.

STRESSES IN A SOLID SHAFT.—By substituting $p = 0$, $X = R$ and $r = 0$ in equations (5) and (6) the stresses at the outer surface of a solid shaft are found to be

$$S_h = -p' \qquad (17)$$

$$S_r = -p' \qquad (18)$$

By substituting the values $p = 0$, $X = r$ and $r = 0$, the stresses at the center are similarly found to be

$$S_h = -2p' \qquad (19)$$

$$S_r = 0 \qquad (20)$$

The equivalent stress produced by S_h and S_r at the surface of the shaft is

$$S_1 = S_h - \lambda_1 S_r = -(p' - \lambda_1 p') \qquad (21)$$

By assuming $\lambda_1 = 0.3$, it is found from this equation that the equivalent stress at the center of the shaft is nearly three times as great as that at the surface.

Relation Between Stress and Allowance for Fit.

Denoting the equivalent hoop stresses in the shaft and ring by S_1 and S_2 respectively, the unit deformations in the direction of the tangent are

$$\frac{S_1}{E_1} = \frac{D_1 - D}{D_1} \text{ and } \frac{S_2}{E_2} = \frac{D - D_2}{D_2}$$

By adding these equations,

$$\frac{S_1 D_1}{E_1} + \frac{S_2 D_2}{E_2} = D_1 - D_2$$

Then dividing by D_2, the unit allowance is

$$d = \frac{D_1 - D_2}{D_2} = \frac{D_1}{D_2}\cdot\frac{S_1}{E_1} + \frac{S_2}{E_2} = \frac{\frac{S_1}{E_1} + \frac{S_2}{E_2}}{1 - \frac{S_1}{E_1}} \qquad (22)$$

From equation (12) the pressure acting against the inner surface of the ring is

$$p = \frac{S_2}{K + \lambda_2}$$

and by equation (21) the pressure on the surface of the shaft is

$$p = -p' = \frac{S_1}{1 - \lambda_1}$$

By eliminating p in these equations the relation between S_1 and S_2 is

$$S_1 = S_2\frac{1 - \lambda_1}{K + \lambda_2}$$

which by letting

$$y = \frac{1 - \lambda_1}{K + \lambda_2}$$

reduces to the simpler form

$$S_1 = y S_2 \qquad (23)$$

Equation (22) may now be written

$$d = \frac{\frac{S_1}{E_1} + \frac{S_1}{y E_2}}{1 - \frac{S_1}{E_1}} = \frac{\frac{S_2}{E_2} + \frac{S_2 y}{E_1}}{1 - \frac{S_2 y}{E_1}} \qquad (24)$$

The denominator is so near unity that it may be neglected and the equation reduced to

$$d = \frac{S_1}{E_1} + \frac{S_1}{y E_2} = \frac{S_2}{E_2} + \frac{y S_2}{E_1} \qquad (25)$$

By solving this equation, the equivalent hoop stresses are

$$S_1 = \frac{d E_1}{1 + \frac{E_1}{y E_2}} \qquad (26)$$

and

$$S_2 = \frac{d E_2}{1 + y\frac{E_2}{E_1}} \qquad (27)$$

Substituting the value of p given by equation (7), equation (12) reduces to

$$S_2 = S_{h_2}\left(1 + \frac{\lambda_2}{K}\right)$$

From equations (17) and (18), $S_{h_1} = S_{r_1} = p'$, which substituted in (21) gives

$$S_1 = S_{h_1}(1 - \lambda_1)$$

By substituting these values in equations (26) and (27) (bearing in mind the value of y) the actual hoop stresses in the shaft ring are

$$S_{h_1} = \frac{d E_1}{1 - \lambda_1 + \frac{E_1}{E_2}(K + \lambda_2)} \qquad (28)$$

and

$$S_{h_2} = \frac{d E_2 K}{K + \lambda_2 + \frac{E_2}{E_1}(1 - \lambda_1)} \qquad (29)$$

These equations (28) and (29) apply to rings on solid shafts and are equally true for cast iron, steel and other metals. For the case of cast-iron rings on steel shafts the above equations may be simplified by substituting the constants of the materials, which may be taken as follows: $\lambda_1 = 0.3$, $\lambda_2 = 0.25$, $E_1 = 30{,}000{,}000$. The value of E_2 for cast iron varies with the stress, but if the stress does not exceed 7,000 lbs. per square inch it may be taken as 15,000,000. Hence for a cast-iron ring on a steel shaft

$$S_{h_1} = \frac{15{,}000{,}000\, d}{K + 0.6} \quad (30) \qquad \text{and} \qquad S_{h_2} = \frac{15{,}000{,}000\, d}{1 + \frac{0.6}{K}} \quad (31)$$

Since by equation (17) the hoop stress in the shaft is numerically equal to the external pressure, S_{h_1} in (30) is equal to the unit pressure between the surfaces.

For the case of steel rings shrunk on shafts of the same material

$$S_{h1} = \frac{30{,}000{,}000\ d}{1 + K} \text{ and } S_{h2} = \frac{30{,}000{,}000\ d}{1 + \frac{1}{K}}$$

For convenience a few values of K are given as follows:

Values of t/r,	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.25	1.5	1.25	2.0	3.0
Values of K,	3.0834	2.6000	2.282	2.058	1.892	1.766	1.666	1.492	1.380	1.300	1.250	1.133

Examples Showing Application of Formulas.

To show the application of the above formulas, the solutions for a few cases are given as follows:

CASE I.—A cast-iron ring 3 ins. thick and 8 ins. broad is forced on a steel shaft 10 ins. in diameter and it is required to find the stresses in the ring and shaft.

The total allowance as given by Mr. Moore's formula is 0.0205-in., making the unit allowance equal to 0.00205-in. The ratio $t/r = 0.6$ and from the preceding table, $K = 2.282$.

The hoop stress in the shaft and the unit pressure on the surfaces in contact is found by equation (30) to be

$$S_{h1} = \frac{15{,}000{,}000 \times 0.00205}{2.282 + 0.6} = 10{,}669 \text{ lbs. per sq. in.}$$

By equation (31) the hoop stress in the ring is

$$S_{h2} = \frac{15{,}000{,}000 \times 0.00205}{1 + \frac{0.6}{2.282}} = 24348 \text{ lbs. per sq. in.}$$

This value should be the same as that obtained by substituting S_{h1} for p in (7) which gives 24,333. The small discrepancy of 15 lbs. is due to neglecting the second term of the denominator in (24) and to not carrying the value of K to more than three decimal places.

The hoop stress in the ring is near the ultimate strength of cast iron and is entirely too great. For such high stresses the value of E_2 should be less than 15,000,000, which would effect a slight decrease in the above value, but unless the ring is made of good material it will probably fail at the inner surface. Small collars shrunk on shafts have been known to fail before they cooled, whereas the same collars could be forced in place without breaking and give satisfactory results. This is probably due to the fact that the inner surface of the collar cooled faster than the outer surface, making the extension at the inner fibers proportionately greater than that at the outer; and the stress due to the increased extension was sufficient to cause failure. The increase in stress due to this unequal cooling was comparatively small. Hence it is reasonable to suppose that the stress in the unheated collar due to the forced fit was near the ultimate strength of the material.

For a hoop stress at the inner surface of the ring equal to 6,235 lbs. per square inch, the value of $d = 0.000525$-in., which seems to show that the value given by Mr. Moore's formula is excessive. The results indicate that either the value of d was too large or t/r too small.

CASE II.—By using a value of d equal to half the value used in Case I., the stresses are $S_{h1} = 5{,}335$ and $S_{h2} = 12{,}174$ and the hoop stress at the outer surface of the ring by equation (9) is equal to 6,834 lbs.

CASE III.—By increasing the thickness of the ring to 5 ins. and making $d = 0.00105$ the stresses become $S_{h1} = 6{,}950$ and $S_{h2} = 11{,}580$, which shows how increasing the thickness of the ring increases the stress in the shaft and decreases the stress in the ring. In this case the stress at the outer surface of the ring by equation (9) is 4,640 and by equation (11) the equivalent hoop stress at the inner surface is 13,318. The equivalent hoop stress at the surface of the shaft by (21) is 4,865 and the stress at the center by (19) is 13,900.

Pressure Required to Force Ring on Shaft.

The total normal pressure between the surfaces of ring and shaft is

$$P = p\,\pi\,D\,b$$

Hence the pressure required to force the ring on the shaft is

$$F = P\,\mu = p\,\pi\,D\,b\,\mu \qquad (32)$$

The pressure required to force the ring in Case III. on the shaft, as found by assuming a value of $\mu = 0.12$ in equation (32) is 105 tons.

Torsional Resistance of Fits.

The resistance offered by a forced fit to a twisting moment is

$$P\,\mu\,r = p\,\pi\,D\,b\,\mu\,r$$

and by equating this to the torsional resistance of a solid shaft

$$p\,\pi\,D\,b\,\mu\,r = q\,\frac{D^3\,\pi}{16}$$

which may be written

$$q = \frac{8\,b\,\mu\,p}{D} \qquad (33)$$

The coefficient of friction depends upon the nature of the surfaces fitted and the lubricant used and may be determined by experiment. It is quite probable that the value of μ in equation (33) is greater than the value used in equation (32).

The unit shearing stress in the shaft in Case III. at the instant the ring would move when subjected to a twisting moment as found by (33), assuming $\mu = 0.12$ as before, is 5,340. This suggests the use of keys in connection with forced fits.

Conclusions.

Some of the conclusions to be derived from the above investigation and examples may be stated as follows:

The allowances for forced and shrinkage fits should be based upon the stresses they produce and not upon the diameter of the shaft.

In many fits, the stress at the inner surface of the ring is near the point of failure.

The torsional resistances is not usually equal to the resistance of the shaft, hence it is necessary to use keys in order to have the factor of safety of the fit in this particular equal to that of the shaft.

The stress at the center of a solid shaft is 2.85 times as much as the equivalent stress at the surface.

The stresses and the holding power are not independent of the radial thickness of the ring.

Annual Meeting of the Illinois Water Supply Association.

The annual meeting of this association (which was organized in 1909) was held at the University of Illinois (Urbana and Champaign) March 8 and 9. There was a fair attendance of members and visitors, while that of professors and students helped materially in rounding out the meetings. The association has now about 140 members, and has a small cash balance, but it decided to increase its dues in order to provide sufficient funds to carry on its business. The officers elected were as follows: President, C. E. Slocum; Vice Presidents, O. T. Smith, R. R. Parkins and C. H. Cobb; Secretary and Treasurer, Dr. Edward Bartow (Director of the Illinois State Water Survey), Urbana, Ill.

At the opening meeting on the afternoon of March 8, in the lecture room of the Engineering Building, a brief address was made by the president, Mr. D. H. Maury, M. Am. Soc. C. E. Dr. W. F. M. Goss, Dean of the College of Engineering, followed with an address on "The Greatest Need of the Water-Supply Industries of Illinois," this need being a more general utilization of men of expert and technical training. We abstract some parts of this address below, as it is applicable elsewhere than in Illinois:

In the New England and northern states the streams are numerous and clear, ponds and lakes of clear water are numerous, and an abundant supply of water is everywhere available. The great engineering enterprises are simple in conception and plan, and are free from many of the difficulties which must be overcome in an attempt to supply an equal number of people in cities in the Mississippi valley. Cities in Illinois find natural waters equal in purity with those of New England unobtainable. Some find the supply of whatever quality deficient, and all must pump the supply once, while many must pump it twice. If wells are used, the water is so highly mineralized as to be hard. If streams are resorted to, sediment in varying amounts is added to the chemical impurities. A water company must choose where no choice that can be made will be satisfactory. The company must proceed to develop elaborate and expensive arrangements for improving the quality of the water, or provide for such work in the future, or else it may deny its responsibility and give an unsatisfactory supply. The company's official is not always free to choose. He is responsible for the success of a business, and his company must earn a return upon the capital invested.

What is needed is education that will lead to a better understanding of the problems by the officials and the consumers. More and better men will be needed in the future, and this is said without forgetting the great services already rendered by engineers. My argument is for the future, that the larger undertakings which are yet before us may be in hands so skillful as to ensure (in spite of natural difficulties) good water and high efficiency in its treatment and distribution. It is not that experts are needed by water companies alone. Expert and technical ability, whether in the supply house (great or small) from which material is obtained, in the offices of the engineers of cities, or in the offices of private consulting engineers, constitutes a reserve upon which the companies can draw and an influence which will have its effects upon future undertakings.

Improvement in service usually involves an increase in capital invested or in cost of operation, or both, and the burden of this must be borne by the consumer. The extent to which a company is hampered in its legitimate and urgent undertakings is but imperfectly understood by the masses of the people, and when they are required to depend solely on the explanations of the company's representatives they are inclined to discount the argument. They may want better service, and may even be willing to pay something for it, but are distrustful. If there were more men who could see the problem in a broad light it would be a help.

This does not mean that every street corner must have the office of a consulting engineer (though most communities would be benefited if they had more such offices). But it does mean that there must be more manufacturers, merchants, bankers, etc., who in their academic preparations for life have followed scientific or technical lines. In fact, a college course in engineering is coming to be recognized as an excellent preparation for a business career. A few such men could do more for the public service of a city than any other single influence. The water companies themselves must have men of higher quality and better training for staff positions, and should look to the engineering colleges for their supply of such men.

Three papers were presented in regard to wells for water supply. Mr. F. C. Amsbary (Superintendent of the Champaign & Urbana Water Co.) discussed "Experience with Deep Well Pumps," and drew comparison between pumps and air-lifts, stating that the latter require more power for raising the same amount of water. Mr. C. B. Burdick (Chicago) thought that some other type of pump other than the plunger type should be considered. He suggested that comparisons should be made as to cost of maintenance of different types of well pumps, as this is one of the very important items, but as to which very little information is available. Mr. Burdick presented also a paper on "The Chances of Pollution in Shallow Wells," referring to municipal wells drawing supply from the sands and gravels overlying bed rock. Of this we shall give an abstract later. Prof. A. N. Talbot outlined the results of some investigations as to "The Rate of Flow of Water into Wells." A paper on "A City Water Supply from Wells," by Mr. O. T. Smith (Superintendent of Water-Works at Freeport, Ill.) was read by title.

Another group of papers dealt with water purification. An illustrated paper on "Filtration of Water Supplies," by Mr. J. Langdon Pearse (Assistant Engineer of the Sanitary District, Chicago) briefly described several recent plants of large size. Three papers dealt with the new "hypochlorite" (bleaching powder) process. Prof. C. E. A. Winslow (Mass. Inst. of Technology) reviewed it in a paper on "Disinfection of Water," especially in regards to the plants at Jersey City and the Chicago stockyards, and suggested fur-

ther tests as to its effect upon certain specific bacteria. Prof. Burrage (Purdue University) advocated sprinkling the dry powder over the surface of the water in the tank, so that it will pass down through the water. Mr. H. E. Jordan (Chemist of the Indianapolis Water Co.) stated that this could not be done in large plants. He presented a paper on "The Practice and Devices Used in Applying Hypochlorite." Mr. W. R. Gelston (Supt. of the Citizens Water Co. of Quincy, Ill.) described "Bleaching Powder as an Adjunct to Filtration at Quincy, Ill." The unfortunate use of an overdose in the first attempt "developed an abnormal sense of smell and taste in some of the consumers," and complaints continued for several months, with little real cause. He thought no odor or taste was produced with less than 0.14 grains per gal. Mr. C. E. Thomas (General Foreman of Water-Works, Illinois Central Ry.) presented some notes in comparison of hydrated lime and ordinary lime in water treatment.

As to water supply in general, Mr. R. B. Dole (U. S. Geological Survey) gave a paper on "The Quality of the Waters of the Mississippi System." Prof. E. W. Washburn (Chemistry Dept., University of Illinois) discussed "The Significance of the Term Alkalinity in Water Analysis," and illustrated by chemical tests a method of determination of the alkalinity. "Legislation in Relation to the Pollution of Streams" was dealt with in a paper by Mr. H. M. Ely (Supt. of the Danville Water Co.), while Dr. Bartow presented the paper on "Water Supplies and Typhoid Fever in Illinois," which was published recently in our columns. Mr. W. F. Monfort (Chemist of the St. Louis Water Dept.) described "The Action of Mississippi Water on Metals," and exhibited the works of some water meters affected by corrosion and scale. A paper by Mr. T. A. Alvord and L. I. Birdsall (Chicago) on "The Sanitary Condition of Water in Inlet Tunnels" was read by title; it showed an unexpected amount of pollution due to construction work, necessitating continued and expensive pumping for flushing.

Three papers of a general character may be noted also: (1) "Shall Water Companies Furnish the Private Services Free, up to and Including the Meters," by Mr. E. P. Wheeler (Superintendent of the Lake Forest Water Co., Ill.); this took a strong position on the affirmative and is noted elsewhere. (2) "Water-Works Franchises," by Prof. M. H. Robinson (University of Illinois); he took the ground that company ownership is the better if proper economic relations between the city and the company can be established. He favored the "indeterminate franchise" system now in use in Wisconsin, and suggested that if the company paid a percentage of its profits to the city, the latter have an inducement to work in harmony with the former, while the disadvantages due to political influences in municipally-owned plants would be avoided. (3) "A State Bureau of Municipal Information," Prof. J. W. Garner (University of Illinois) referred to the bureaus organized in several cities (of which Baltimore was the first) to furnish information as to practice in various municipal matters. To avoid duplication of work and expense, he advocated the establishment of a state bureau, to be operated in connection with the state university where a large library and a staff of experts is available.

On none of the papers was there any extended discussion, although several were of such a character as to invite it.

The entertainments included admission to the annual concert of the University Military Band and a "dinner" following the concert.

Reinforcing Compression Members of Concrete in a Plane Transverse to the Line of Thrust.*

By ROBERT A. CUMMINGS,† M. Am. Soc. C. E.

This paper will serve to bring the study of reinforced concrete in compression to your attention by referring to a proposed method of reinforcement applicable to compression members built in a horizontal or inclined position.

When a solid is acted upon by a compressive force, there are set up internal stresses that tend to disrupt its structure. These forces may be termed cohesion and friction. Cohesion is the force by which the molecules hold together. Friction is resistance of the molecules to motion. Sand may be considered as a cohesionless body while its resistance to compression is due to friction only. If a tube is filled with sand to a limited height and subjected to pressure, there is a tendency for the tube to bulge outward, which is resisted by the metal shell. When the tube is filled with concrete and subjected to pressure, the resistance is increased by molecular cohesion and less lateral pressure is exerted on the tube. Assuming that the coefficients of friction are the same, the difference between the resistances of the sand and the concrete is the effect due to cohesion. The stress on hooping varies from a maximum with a cohesionless material to a minimum with neat cement. The value of cohesion for various concretes are yet to be determined.

If a prism of concrete be placed in a compression machine and subjected to a compressive force, it is the universal custom to treat the prism as having failed in direct compression and to assume its strength equal to the sectional area divided by the load. This theory has led up to a general misinterpretation of internal stresses in compression tests. The characteristic pyramidal shaped failures of cubes in compression is due to the friction between the plates of the testing machine and the specimen by preventing lateral displacement of the molecules. The introduction of a greased surface has reduced the friction sufficiently to show that failure takes place along the lines parallel to the direction of the pressure after the elastic limit of the material has been exceeded. In consideration of this fact, experimental studies have been made by placing reinforcement at right angles to the direction of pressure and at variable distances apart. The result of the experiments on metal sheets has conclusively shown that the strength of concrete can be greatly increased. It has also shown that the results are due to the close spacing of the layers of reinforcement and further verifies the well known increased compressive resistance of mortar in the joints of masonry.

The tests referred to also indicate that the best percentage of reinforcement is capable of being determined within reasonable limits or that which produces the greatest result with the least amount of steel.

In almost all construction in reinforced concrete, practical methods largely govern the distribution of steel. This is particularly true in column work where the concrete is placed vertically so that the use of wire netting or sheet metal in horizontal layers is out of the question. Hooping remains only the practical method of safely increasing the unit compressive strength of concrete for such work.

But in inclined compression members where the concrete is deposited on one side of the member, the difficulty of using lateral reinforcement is reduced and some time ago the writer suggested the use of concentric and interlocking hoops combined with longitudinal reinforcement for resisting shear in arch ribs. This has been followed by some of his experiments on the effect of lateral reinforcement using different weights and disposition of the steel. These tests were not carried out with the degree of refinement and accuracy desired, hence simply indicate what one might look for in further studies. They are shown in the accompanying table.

An examination of a curve plotted from the ultimate load and percentage of reinforcement indicates strength value directly proportional to the amount of reinforcement. Also that the best disposition of the steel is that which intersects the resultant of the meridianal forces and the lateral deformations.

The writer has applied the proposed method of lateral reinforcement in his practice with very encouraging results, particularly in concrete piles cast horizontally on the ground.

The extraordinary severe treatment to the head when the hammer strikes a concrete pile is not duplicated in any other class of work. In a case where the reinforcement was distributed in wire spiral planes spaced two inches apart in the head of the pile, a test was made on a pile about 30 days old. A hammer weight 6,500 lbs. was used, falling from 4 to 7 feet. This pile was driven through very sandy gravel into a bed of fine sand during a period of 3½ hours. About 900 blows were struck on the head of the pile with no deterioration to the concrete. This work opens up a broad field of usefulness for the proposed method of reinforcement.

*Portion of Paper read before the Annual Meeting of the National Association of Cement Users, Chicago, Ill. Feb. 21-25, 1910.

†Consulting Engineer, Pittsburg, Pa.

TABLE GIVING DATA ON TESTS OF SHORT CONCRETE COLUMNS REINFORCED IN TRANSVERSE PLANES WITH FLAT PLATES OF WIRE OR BANDS.

No.	1	2	3	4	5	6	7	8	9
Kind of Reinforcement	Band Hoops.	Band Hoops.	Plain Concrete.	Concentric Circles.	Wire Mesh.	Metal Lath.	Looped Wire.	Wire Spiral.	Plain Round Hoop.
*Dimensions of Reinforcement	⅝" x No. 8 7" Diam.	1" x No. 16 7" diam.	.....	No. 7 3", 5", 7" Dia.	1⁷/₁₆"×No. 6	1⅝"×3"×No. 9	No. 7	No. 7 3½ turns	⅝" ϕ x 6.3" Diam.
Spacing of reinforcing planes c. to c.	2"	2"	.....	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"
Actual weight of Reinforcement	6 lbs. 14½ oz	4 lbs. 10¼ oz.	.....	3 lbs. 13½ oz.	6 lbs. 9 oz.	3 lbs. 13½ oz.	3 lbs. 3 oz.	3 lbs. 15 oz.	11 lbs. 13 oz.
Cu. in of Reinforcement	24.38	16.34	.....	13.58	23.19	13.58	11.26	13.91	41.74
Size of Specimen	8" diam. 24" long	8" Diam. 24" long	8" Diam. 24" long	8" Diam. 24" long	8" Diam. 24" long	8" Diam. 24" long	5"×10" sq. 24" long	8" Diam. 24" long	8" Diam. 24" long
Cu. in. of Specimen	923.64	923 64	1206.38	923.64	1206.38	1206.38	1200	885.80	748 15
Percentage Reinforcement, vol. to concrete vol	2.64	1.77	.....	1.47	1.92	1.12	.94	1 62	5 58
Cross Section of Specimen, sq. ins.	‡38.485	‡38.485	50.266	‡38.485	50.266	50.266	50.00	‡35.787	‡31.173
Ave. shortening in per cent. length of specimen	.....	.....	.....	1.91	1.47	1.53	1.38	1.67	3.8
†Ave. Ult. Load in lbs	100,845	87,155	51,125	87,825	97,030	91,547	63,908	91,247	147,923
†Ave. Ult. Load per sq. in. in lbs.	2768	2265	1017	2281	1930	1821	1278	2550	4745
†Ave. Ult. Load in lbs. per sq. in. per percentage of Reinforcement	1048	1280	.....	1632	1005	1626	1,360	1574	850
†Ave. Ult. Load in lbs. per sq. in. per pound of Reinforcement	401	486	.....	593	294	474	401	648	401

*All numbers in this line are in B. & S. gage.
†Each value the average of three test specimens.
‡Cross section of core only.
Note: In all specimens except Nos. 1 and 2, reinforcing planes were found out of position some being as much as 2½" apart on one side. Hence these tests are not satisfactory and cannot be accepted as conclusive.

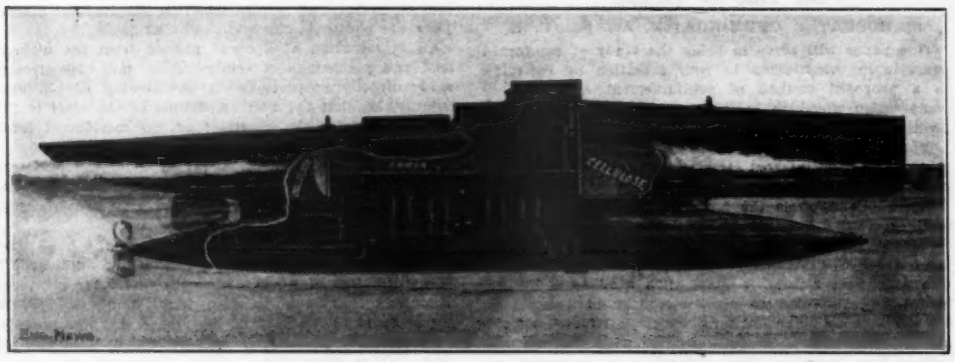
TOLL RATES IN PENNSYLVANIA are to be abolished, according to a plan now under consideration by the State Toll Roads Commission, of which Senator Oscar E. Thomson, of Phoenixville, Pa., is Chairman. There are 220 toll road companies in Pennsylvania, owning 725 miles of roads. Most of these roads are in the thickly settled farming districts in the eastern part of the state. Lancaster County has 156 miles of toll road, representing an investment of $600,000; Bucks County has 105 miles and Montgomery County 93 miles. Editorial comment on the abolition of the last toll gate in the city of Philadelphia during the year 1905, was printed on p. 155 of our issue of Feb. 8, 1906.

AN INTERNATIONAL MUNICIPAL EXHIBITION and Congress is proposed by Chicago, to be held in September or October, 1911, and the city council has passed a resolution in favor of the project. According to the preliminary statement, the prominent municipalities of the world will be invited to make exhibitions of particular features marking the progress and the science of municipal government in their communities. Municipal and civic organizations will be asked to send delegates to take part in conferences for the various sessions of the Congress.

Among the exhibits proposed are all branches of municipal undertakings, including engineering, paving and road-building, sewers, bridges, concrete construction, water-works, gas and electric street lighting, street railways, telephones, garbage collection and disposal, street cleaning and sprinkling, fire and police organization and equipment, sanitation and health, forms of municipal government, municipal accounting, parks and playgrounds, charities and corrections, civic art, boulevards, hospitals, police courts and treatment of crime and criminals, control and regulation of liquor traffic, manner of levying taxes and fixing tax values, public service franchises, etc.

A Boat-Torpedo of Enormous Destructive Power, Carrying Its Own Gasoline Engine and Crew.

The most recent development in torpedo boat construction is a new type which is midway between an ordinary torpedo boat and a Whitehead torpedo. It consists of a submarine hull, which contains all the machinery and the explosive charge, suspended beneath a surface hull rendered unsinkable by a series of compartments packed with cellulose. The Naval Appropriation Act of 1909 authorized the purchase of this boat for the U. S. Navy provided it can fulfill requirements in the Government tests. These tests are shortly to be made at Boston.



SEMI-SUBMARINE BOAT-TORPEDO FOR THE U. S. NAVY.

The general appearance of the boat-torpedo is shown in the accompanying illustration. The submarine portion has the typical cigar-shape of the Whitehead torpedo and contains both the destructive and propulsive equipment. In the forward end is the explosive charge of 1,000 lbs. of gun cotton and behind this is the gasoline engine which drives the screw propeller at the stern. The surface hull is shaped like the hull of an ordinary surface boat and its function is to support the excess weight of the sub-surface hull and to carry the conning tower in which the two operators are stationed. The illustration does not show the boat's true proportions.

In operation, the boat torpedo is to be navigated by its crew of two men to within what may be considered sure striking distance of the hostile battleship. The helm is then locked, with the prow aimed at the mark, and the engine is set at full speed ahead. The crew of the boat-torpedo is expected to abandon it at this juncture in small boats or life buoys. With good luck they may be rescued by friends later. It will relieve those readers who sympathize with the daring crew in this dilemma to learn that possibly an alternative design may be adopted fitted instead with a submerged bow torpedo tube for discharging an ordinary 18-in. torpedo.

There are compelling advantages, however, connected with the design as shown in the illustration. The length of the submerged, or torpedo, hull is about 30 ft., as compared with the 16-ft. length of the ordinary 18-in. torpedo. Its larger size gives room for the mammoth charge of 1,000 lbs. of gun cotton—about eight times the weight of explosive carried by the 18-in. Whitehead type. The eight-cylindered gasoline engine is mounted in the midships portion of the submerged hull and develops 150 horsepower. The engine and rudder are controlled from the conning tower directly above in the surface hull, which communicates through a hatchway with the engine compartment. The rudder is located in the V-shaped space between the sterns of the two hulls.

The conning tower is protected by heavy armor which is also extended over the floor as additional protection to the power plant below. The surface hull itself is 45 ft. 9 ins. long with a beam of 5 ft. 4 ins. The weight of the entire vessel is given as six tons and its draft as 3 ft. 9 ins. The surface hull is protected by cellulose packed within its double walls. This, it is claimed, makes the boat unsinkable and practically immune from serious injury by the comparatively small guns ordinarily relied upon for defense against torpedo attacks. In the illustration, a dotted white line will be found five or six feet back from the surface hull's prow, marking the extent of its soft collapsible nose. Upon striking the side of a ship at good speed, this soft nose crumples up and allows the warhead of the shorter torpedo hull to get into action.

The required speed of 16 knots has been excelled, we are informed, in preliminary trials made by the builders in which a speed of 18 knots was attained without difficulty. The cruising radius of the boat-torpedo at 10-knot speed is 200 miles, which limits its field of action to the defense of ports and neighboring coast line unless, indeed, small boats of this type be carried on board larger vessels. They could then be launched and used against an enemy's fleet in foreign harbors or, under favorable weather conditions, in the open sea. The price to be paid for this boat of the size described is $22,500. Provided this first boat is approved in the coming trials, the Navy Department is authorized to contract for one other of the same size and one larger and faster boat of the same type to cost $400,000. The larger boat torpedo will be known as a "subsurface seagoing destroyer."

The present vessel was constructed at a Boston shipyard last year after designs prepared under the direction of Tams, Lemoine & Crane, consulting naval architects, of New York City. The inventor of this new type of vessel is Mr. Clarence L. Burger, of New York City. Mr. Burger received the degree of Civil Engineer from Princeton University in 1885.

Should Water Companies Furnish Free the Private Services, Up to and Including the Meters.*

By E. P. WHEELER.†

Many water-works managers and superintendents are not satisfied with the current practice of charging for private services and meters, because of the many objections against the practice. On the other hand, they are not sure that a change to a free service and a free meter is the next step to be taken. It seems to me that water companies are justified in furnishing the meters free to their customers, and the private services as well, at least up to the meter. This is because, so far as the meter is concerned, it falls into line with general business usage, by which the seller furnishes the means of measuring or weighing the articles he sells. To deliver the water to the purchaser as measured requires that the water company should furnish the meter at its own expense. If we compel the customer to pay for his own meter, he submits of necessity, and not because he is convinced it is right. This unsatisfied sense of fairness is not a good asset for the company, and it lays the foundation for discontent with everything in which the company has to do with the consumer. This charging of the meter upon the consumer is one of the acts which justly invites a feeling of unfairness on his part, and for this reason the company should furnish the meter.

The mains are brought to the street in part of the consumer's property by reason of the hydrant rental paid by the city. To make him pay for the service not only across his property, but from the property line to the mains, seems to him unjust, especially as he has no right to lay or repair the private service in the street without a permit from the city or the company. In other words he is compelled to invest in property that he cannot directly control. Another reason is that the practice is in accord with that of other public utilities, especially the gas companies. In cities like Chicago the gas companies put in all services free, up to and including the meters. In country towns, this free service is limited to 60 or 65 ft. from the mains. Electric light companies are following more and more in the same lines.

One of the most common sources of loss to water companies is the waste through leaky services, and under the present methods we have to make the patron repair these fixtures and connections. This aggravates his feeling of injustice, especially as he thinks the repairs are for the company's benefit and not for him, and he is unwilling to incur the expense unless compelled to do so. He naturally wants his service put in as cheaply as possible, and in spite of all our rules and inspection, the material and work are not as good or as effective as if we did the work. The courts will not back us up in demanding of our customers the kind of connections we would put in. This has been tried. The companies have tried also the plan of putting in the service pipes and connections at cost, so as to secure better work and less leakage, but this brings them into collision with the plumbers. Besides this, the consumer will be shy of patronizing the company as against outsiders if the prices are not widely different.

In one of the plants under my control, I have started a method whereby the service pipes are entirely done away with in the streets. This is accomplished by putting the fire main in the terrace part of the street, and putting a 4-in. cast-iron main in the terrace part of the other side of the street. At a point where the private service is to be connected into these mains, a bricked meter pit is located; and in such a manner that the main shall barely enter the street side of this bricked pit. This enables connecting the service to the main where its condition can be easily watched, and its leakages remedied, if any. This bricked pit also serves to enclose the cut-off valve or stop cock, which also can be easily watched, and kept from leaking. This also does away with the Buffalo box, and with the necessity of digging it up, when you want to cut off the stop cock, because the frost has heaved it to one side of the center of the cock. Of course, this method of attachment can only be employed where extensions are to be made, and the mains laid so as to conform to the requirements of this method.

An objection raised to the free meter and service is that the returns for water under conditions of minimum rate charge do not afford sufficient returns to make the investment pay. The following figures, taken from the records of one of our small plants, are suggestive. The cost of a ¾-in. service upon a street 4 rods wide, including the meter pit and the meter, was inside of $30. Allowing 15% for interest on such investment and depreciation charges, we have $4.50 as the annual charge against such a service. Our minimum rate at this plant and for such free meter and service connections is $10. The average amount of water pumped through such services, where the minimum rate applied, was less than 20,000 gals. during the year. In other words, we got $5.50 for pumping 20,000 gallons of water through those free meter and free service connections. Thus, after amply providing for the cost of the investment in such services, we got pay for the water at the rate of 27½ cts. per 1,000 gallons. So far as this experiment has gone, we have had no reason to complain about the paying character of the investment.

We find in our experience that the response to a free meter and free service policy immediately precipitates a large number of orders for water from classes who would otherwise have waited for years for the connection. The addition of this class of customers is an advantage in many ways. In small communities it may make the whole difference between a paying plant and one that is not. Where you have just enough customers to pay running expenses, and fixed charges, a very small increase in the use of water will make the plant pay, where it is not paying. This for the reason that where a plant is barely paying expenses, any increase in the water pumped is nearly all profit, and so of double advantage.

*Abstract of a paper read at the annual meeting of the Illinois Water Supply Association, held at the University of Illinois, March 8 and 9.

†Superintendent and Manager, Lake Forest Water Co., Lake Forest, Ill.

MUNICIPAL OWNERSHIP OF THE STREET RAILways of San Francisco has received a setback in the form of an injunction restraining the city from constructing the proposed Geary St. line. Bonds for this line were voted a few weeks ago. No other street railway construction is contemplated for the present, but the most ardent friends of municipal ownership hoped that this would be the opening wedge for the municipal ownership of the street railways of the city. A permanent injunction against the Geary St. line is sought on the ground that private companies operating under existing franchises have prior rights in lower Market St. and in sections of Geary St. and Point Lobos Ave.; that the city authorities violated a provision of the city charter in not offering to buy the existing street railway before taking steps to build on the same street; and that certain formalities were not observed in submitting the proposed bond issue to popular vote.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.
220 BROADWAY, NEW YORK

BRANCH OFFICES
CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

GEORGE H. FROST, President
CHARLES WHITING BAKER, Vice-President
HARWOOD FROST, Secretary
FRANCIS W. FROST, Treasurer

ALFRED E. KORNFELD, Manager
EDWIN HUNT FROST, Ass't Manager

CHARLES WHITING BAKER, M. N. BAKER, E. E. R. TRATMAN, F. E. SCHMITT, } Editors

SUBSCRIPTIONS

United States and Possessions, Mexico and Cuba, One Year, $5.00.
Canada, One Year; $7.00; Thin Paper Edition, $6.00.
Foreign Countries, Regular (Thick Paper) Edition, One Year $9.00. (£1-18-0.), 45 Francs or 37 Marks.
Foreign Countries, Thin Paper Edition (Construction News Supplement Omitted), $7.00. 29 Shillings, 35 Francs or 29 Marks. Remit directly to our office.
Pay no money to canvassers for subscriptions.
Remit by Post-Office or Express Money Order, Draft on New York or London, or by Registered Letter.
Notice of change of address should reach us one week in advance of removal. The old as well as the new address should be sent.
Subscriptions cannot be dated to commence with past issues. All subscriptions commence with current issue and back numbers can be supplied only by special order.
Receipts for Subscriptions will not be sent unless requested, the changing of the expiration number being considered sufficient. The number on the address label indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year. Thus 520 means the 52d week or December 29, 1910.

ADVERTISING

"Contract": Rates furnished on application.
"For Sale": $1.50 per inch.
"Proposal": $2.40 per inch.
"Want": See "Want" Pages.

Copy for regular, or "Contract," Advertisements should be received at least ten days before publication; "For Sale" and "Situations Wanted" Advertisements by Monday, and "Proposal" and "Situations Open" Advertisements by 9 A. M. Wednesday.

Entered at the New York Post-Office as Second-Class Matter.

The movement which is said to be on foot to consolidate Oakland, Berkeley and other adjacent California municipalities opposite San Francisco, leads to the question whether or not it is wiser to consolidate municipalities or instead to gain many if not most of the advantages of consolidation by cooperation in the provision of water-supply and other public works which can be best carried out for the communities as a whole. We discussed this question at some length eleven years ago (Feb. 16, 1899), when we called attention to several instances of what we then termed municipal cooperation, notably on the part of Boston and adjacent municipalities, and some of the cities and towns in Essex Co., N. J., including Newark, the Oranges and Montclair.

In discussing the proposed consolidation of the California municipalities, the San Francisco "Chronicle" suggests that a considerable measure of local autonomy would be retained by making use of the borough plan. This, as many of our readers know, was done when Greater New York was formed. There are marked differences of opinion as to how well the plan has worked in New York. Discussions over charter revision during the past year or two have brought out strong arguments in favor of greater unification on the one hand and of still more decentralization on the other. The Administrative County of London, England, affords what is in some respects a possible medium course. There the boroughs are quite independent in a great variety of local matters, but the County Council is supreme in the administration of trunk sewers and sewage disposal, fire protection, and some other classes of public undertakings.

It is interesting to note that when the various water companies supplying London were bought out, the administration of the consolidated works was put in the hands of a metropolitan water board, instead of being entrusted to the London County Council. This was doubtless partly due to a feeling between the borough councils and the County Council, but an additional reason for not putting the metropolitan water-supply in the hands of the County Council was that the supply reaches municipalities outside of the Municipal County of London.

As time goes on, we shall see very much of either municipal consolidation or of joint municipal undertakings by municipalities that otherwise retain their local powers and privileges. This will be particularly necessary in matters of water-supply and of sewage disposal. Lighting and intermunicipal street transportation have already been pretty well taken in hand by consolidated private companies.

It is a generally accepted rule, for securing perfect combustion in steam-boiler furnaces with freedom from smoke and incidentally with the greatest economy of operation, that the furnace temperature must be maintained at the highest possible point. The exposure of water cooled surfaces in the furnace tends to cool the furnace and defeat this end. That there are exceptions to this rule, however, is shown by Bulletin 34 of the University of Illinois Engineering Experiment Station in reporting the results of tests of two types of tile-roof furnaces under a water-tube boiler.

Four boiler trials were made on each of the two types of furnace roofs, placed at different times on the same boiler. The essential difference in the roofs was that the lower row of water-tubes, over the grate bridge wall and combustion chamber, had each tube, in one case, completely surrounded by the tile forming the "roof" and in the other case, had the tile resting on the tubes, leaving the lower half of each tube directly exposed to the flame and gases arising from the grates. The under side of the tubes was from two to four feet above the bare grates. The minimum capacity developed during any one boiler test was 102% of the rating and the maximum was 106%.

When the lower tubes were completely protected by tile the boiler efficiencies (heat absorbed per pound of combustible divided by heat in one pound of the combustible), varied from 64.4% to 66.3% with an average of 65.6%. In the other case the efficiencies varied from 67.5% to 69.4%, the average being 68.6%. That is to say, there is a gain of 3% in boiler efficiency (not including grate) in this case by cooling the combustion chamber. The temperatures in the combustion chamber were from 200° to 400° less with the tubes exposed and the flue-gas temperatures were correspondingly lower. The water evaporated per pound of combustible fired was 5% more with the tubes so exposed to the flame and gases. No smoke at all was made with the tubes fully protected and but a little, of unobjectionable color, with the tubes exposed and working at full rated boiler capacity. In short, the "half-tiled" roof proved superior in boiler efficiency, maintenance and simplicity and the "full-tiled" excelled only in higher degree of smokelessness. It is interesting to note, also, that flue-gas analyses showed practically as good combustion in one case as the other, and that with Illinois coal, having 37% volatile matter, 12% moisture and 15% ash.

The point to be remembered in all this is that radiation and stack losses may be increased, by the higher temperatures in a completely protected furnace and combustion chamber, until they surpass the flue-gas losses due to incomplete combustion in the cooled furnace. While a certain amount of tube protection is desirable, to limit the chilling of the furnace and combustion chamber, considerable heating surface may be exposed in a boiler furnace where intense combustion is taking place without cooling the fire to such a point as to cause smoke.

A bill has been introduced in the United States Senate, providing for the inspection of railway locomotive boilers by the United States Government. It received the support of the representatives of railway employees' organizations, but has been opposed by the railway companies generally.

We believe this measure represents a most unwise development of federal supervision over railway operations. The state railway commissions can supervise the inspection of locomotive boilers far better than the Federal Government, unless the latter were to create an enormously expensive bureau for that special work. Furthermore, even the Public Service Commission of New York, which is far more thoroughly organized to carry on the work of state supervision than any of the ordinary state railway commissions, has decided that the railways themselves can carry out the work of boiler inspection better than it can be done by the Public Service Commission. It is true that the Public Service Commission may supervise this inspection as they do all other features of railway operation, but the primary responsibility should be left with the railways themselves.

The principle involved is not dissimilar to that which arises in connection with municipal supervision of building operations. Engineering News has favored proper municipal building regulations and a proper organization to ensure their enforcement. It has strongly opposed the tendency to unload upon the municipality and its bureau of building inspection the responsibility of supervision which should be borne by the owner and the architect.

The end to be attained in either case is public safety, and nothing should be done to lessen the responsibility borne by the party who is performing the work: that is to say, the railway company in the one case, or the constructor of the building in the other.

Fifty years is not a long time in the life of many of the species of trees best suited for timber, but it more than covers the full span of active life of the men upon whom falls the serious duty of providing the future timber supply of this country. And yet how very little is being done to avert the timber famine that threatens the United States even earlier than 1960. Our general government has done a considerable amount of timber-conservation in the west, a little experimental and object-lesson planting, and a large amount of valuable educational work. A few states have followed suit and some have branched out into new lines of forestry work. A goodly number of private corporations and individuals have also entered on forest conservation or extension with intelligent enthusiasm, largely at the suggestion and cooperation of the general or state governments. But after all, only a little has yet been done to meet the immense timber needs of our large and growing country thirty to fifty years hence, to say nothing of the future export demands.

The seriousness of the timber-supply problem is greatly increased, as our opening sentence intimates, by the long period of time required to mature a timber crop. A few fast-growing species may yield a measurable return in 25 years, but, thinning aside, and all species of merchantable timber considered, 50 years is a fair average growth period for a timber crop. Who can be expected to plant trees for use 50 years hence? Except on a relatively small scale it cannot be expected that many private individuals will do so, and we have no law that compels a man to plant a tree for every one he cuts down, as we believe there is, in effect, in some foreign countries. Long-lived corporations may plant for use 10 to 20 years hence (as trees for ties and fence posts), but this still leaves the greater part of the timber problem in the 50-year category. The general run of money-making corporations cannot be expected to plant for use a half century hence.

There seems to be no conclusion to this matter save that the national, state and municipal governments must do nearly all tree planting that is to produce no return short of 50—yes, even under 30 to 35 years.

One thing is very clear and should never be lost sight of: Whatever perplexities and difficulties surround tree planting every one who owns or controls trees already at or approaching maturity can and should make the most of them. To change the old saying: a tree in the forest is worth a hundred in the seedling state.

Town Planning, Housing and Sanitary Reforms in Great Britain.

Notwithstanding the high standards maintained in many fields of British municipal government, reforms there seem to come slowly and in a piecemeal fashion. This is particularly true of changes requiring legislative or parliamentary authority. Thus, much of the health legislation goes back, either in fact or by amendatory legislation, to the public-health acts of 1875. Instead of clearing up complications due to amendatory and supplementary legislation at comparatively frequent intervals, as is done in many of the separate American states, the British habit seems to be one of legislative accretion and decretion over a long period of years.

The foregoing statements are confirmed, in some measure at least, by the Housing and Town Planning Bill enacted by the session of Parliament which recently came to a sudden termination by the action of the House of Lords on the budget for the year just closed. This bill, according to an official explanation issued by the Local Government Board (the London "Surveyor," Dec. 10, 1909) contains a considerable amount of legislation supplementary to previous enactments. It deals with public-health administration, tenement regulation, housing of the working classes, and, last but not least, with town planning.

The legislation on town planning, according to the Local Government memoranda, is "a new departure in Great Britain." As the matter is of much importance in this country as well, we quote from the memoranda as follows:

> Hitherto new centers of population have been allowed to grow up and existing urban areas have been allowed to expand without control or prevision. The result has too often been that the haphazard development of land in the vicinity of urban centers has produced slums, has prevented the orderly growth of towns, and has involved enormous expenditure in clearing sites, widening streets, and providing necessary open spaces. The bill aims at securing in the future sanitary conditions, amenity, and convenience by enabling schemes to be made under which building land will be developed with due regard to future requirements.
>
> With this end in view the Local Government Board are empowered to authorize local authorities to prepare town planning schemes in connection with land likely to be used for building purposes, or to adopt any such schemes proposed by owners of land. The schemes are to have effect, however, only if approved by the Local Government Board.
>
> The bill provides for the payment of compensation to any person whose property is injuriously affected by the making of a town-planning scheme; and, on the other hand, the local authority is empowered to recover from any person whose land is increased in value by the making of the scheme a proportion of the amount of that increase.

This legislation is really remarkable, in view of British conservatism in dealing with land. It is far in advance of anything which has as yet been seriously proposed in this country. But we have need of equally radical legislation to meet some of the pressing problems of municipal growth in the United States.

As most of our readers know, we can scarcely be credited with having anything like town planning in the United States—barring a few exceptions. In the last few years there has been a notable awakening to the need for town planning in this country, but comparatively little has yet come of it so far as municipal action is concerned; that is to say, numerous civic organizations have called in experts to report on municipal improvements making for more consistent, convenient and esthetic city planning, but in relatively few instances has a city even begun to put these recommendations into effect. Such exceptions as there have been relate chiefly to the establishment or improvement of park systems, with connecting avenues or boulevards, and to the grouping of city buildings.

City planning, as related to a distribution of population in accordance with the demands of health, comfort and convenience, is as yet practically unknown in the United States. Overcrowding and squalid conditions of various sorts prevail in most of our larger cities, and what has been done to mitigate these conditions has consisted largely in regulating the character of tenement houses and the number of their occupants.

It will be seen, from the quotation which we have made, that the British proposal involves the laying out of new building areas in accordance with publicly-formulated or supervised schemes. Under this plan, it will be no longer possibe for real-estate owners to lay out streets and erect buildings with utter disregard for the interests of the community as a whole and with no further regard for occupants of buildings to be erected than is ensured by the narrow and often short-sighted idea of what will most benefit the pockets of the real-estate developers.

It is a pity that our American states and cities cannot at once enact similar legislation, modified to meet our local conditions. As matters now stand in many American cities, the municipal authorities have, or at least exercise, no control over the lay-out of streets and the character of street and building improvements, until the real-estate developers dedicate the streets to the municipality. It is hardly likly that for some years to come we shall be able in this country to dictate by municipal authority the class of buildings and the uses to which they shall be put, in the various districts of the city. But it would seem feasible to lay down certain governing conditions regarding the width of streets and the relative proportions of roadway, sidewalk, and grass or lawn spaces, and at the same time to designate what kinds of street and sidewalk surfacing would and would not be acceptable. In some instances it might be feasible, in addition, to prescribe certain of the characteristics of buildings to be erected in different districts.

The recent British legislation extends the power of local authorities to provide at public expense buildings for housing the so-called working classes. Heretofore these powers appear to have been permissive, only, in what are known as urban and rural districts—what we should understand as small towns and country sections. Hereafter the local authorities will be able to provide low-cost houses for rent in urban and rural districts, whether or not the old act of Parliament governing this subject had been adopted. The new bill goes even further, and "contains elaborate provision as to default." That is, if one of the local councils involved refuses to provide necessary housing accommodations for the working classes, the Local Government Board may, by following prescribed conditions, require this to be done. Orders to this end are enforceable by mandamus proceedings. Moreover, the intervention of the Local Government Board may be secured under the new legislation by complaints not only of the county council or parish council or meeting, but also by any four resident householders of the district. Still further, it may be noted that if a county council sees fit to make good defaults of a rural district council on complaint of four householders, the county council may provide housing accommodations.

We hardly need to say that housing at public expense is unknown in the United States—except in the case of paupers, mentally incompetent, and criminals. Until such a practice is adopted in this country, the British housing provisions are interesting rather than instructive.

The American efforts to improve housing conditions are, as our readers know, confined to the regulation of building construction and maintenance and the prevention of overcrowding. Providing quarters at low rent is left to private enterprise, and, with some notable exceptions, the object sought under private enterprise is to produce the maximum of rent with a minimum of outlay. Public control of housing in the interests of sanitation and of general safety of life and limb is left to health, building or tenement departments, the police, and, as a last resort to the courts. Attempts at central administrative control are very rare indeed. The only instance of the kind which we remember is afforded by the New Jersey State Tenement House Commission.

In view of the facts just stated, it is particularly interesting to note that since 1890 there has been a parliamentary enactment in Great Britain intended to guarantee the sanitary condition of certain classes of houses at the time of signing rental leases. As showing past conditions in this respect and the extension of state regulation provided by the new bill, we quote three paragraphs from the Local Government Board memoranda, as follows:

> Sec. 75 of the Act of 1890 enacts that in any contract for the letting of houses for the working classes it is to be an implied condition that the house is at the commencement of the holding in all respects reasonably fit for human habitation, but this section only applies where the rent does not exceed, in London, £20; in Liverpool, £13; in Manchester and Birmingham, £10; and elsewhere, £8. Clause 14 of the bill extends the application of this provision to houses at a rent not exceeding, in London, £40; in a borough or urban district of 50,000 or upwards, £26; and elsewhere, £16.
>
> There are some 3,500,000 tenements of five rooms and less in England and Wales, and, as these by no means comprise all the houses which will come within the purview of the section as now extended, it will be seen that the implied condition as to the fitness of dwellings for human habitation will practically apply to all working-class dwellings throughout the country.
>
> Clause 15, however, is more important still, for under that clause the implied condition as to fitness is to take effect so as to include an undertaking not merely that the house was fit for human habitation at the beginning of the tenancy, but that it shall be "kept fit" throughout the tenancy. And this undertaking is made enforceable by enabling the authority, if necessary, to do the work of rendering the house fit for habitation and to recover the cost from the landlord.

The principle involved in this legislation seems salutary and worthy of consideration in the United States.

Finally, we would call attention to certain features of the new British legislation which provide that hereafter every county council must not only have a medcial officer of health, but that that officer must "devote his whole time to his duties, and consequently will not be able to engage in private practice." The Local Government Board will prescribe the duties of these officers. The county medical officer of health will have some measure of control also over the district medical officers in his county.

So far as we know, Connecticut was the first of our states to provide for county health officers throughout the state with powers of supervision over local health officers. The Connecticut county officers, however, do not, so far as we know, give anything like the whole of their time to the work, and it appears that they are chosen from the legal rather than either the medical or the engineering professions. Some years after the establishment of a county officer of health in Connecticut, provision was made for at least district supervision of local health officers in Pennsylvania. It should be noted that the British county, as a rule, is far more compact and also more densely populated than the American county. The main lesson to be learned from the new British legisaltion, as regards medical officers of health, is that an attempt is made to secure competent men for the position, and that they are required to give their whole time to the very important duties which are entrusted to them, and that these duties include the supervision of health officers in the lesser districts, which officers, naturally, are likely not to be so competent as those employed by the larger unit.

LETTERS TO THE EDITOR.

The "Laws of Friction" Not Yet Upset.

Sir:—A word in regard to the letter by Messrs. Fuller and Manley in your issue of Feb. 17, 1910: I fail to see how their startling experience with a recently installed water sprinkling system for a golf course upsets very seriously any cherished beliefs about the friction of water in pipes. I have figured the case roughly and find that the friction in each of the small lines (¾-in.) would be from 10 to 20 ft. (including orifice heads.) The friction in each arm of the T, which is of 3-in. pipe, 1750 ft. long, carrying 36 gals. per min. at its upper end and 4 gals. per min. at its lower end, would be not much over 5 ft. In the 1620 ft. of 3-in. pipe to the pump, carrying 72 gals. per min., the friction head would be about 27 ft. The total friction head adds up then to about 50 ft. (The friction heads for the two arms of the T should not, of course, be added together, as they are like two separate pipes leading from a reservoir.) The pressure gage at the pump is said to show from 55 to 60 lbs. when the system is working, and as the friction head is about 50 ft. or 22 lbs., and the vertical lift is 55 ft. or 24 lbs., there remains from 9 to 14 lbs. pressure head even if the golf course

is flat. If it has a good slope down hill there is still more pressure head available. The above figures show, it seems to me, that there is not much cause for apprehension that Messrs. Fuller and Manley's golf sprinkling system has done anything prejudicial to Weston's tables of friction heads. Incidentally it might be noted that the 6-HP. engine, if it is well built and is given a little care, is likely to continue to lift the water whenever required to and will probably not collapse suddenly from doing too much work in its youth.

Very truly yours,

Frank S. Bailey.

Assistant Engineer with Wm. S. Johnson, 101 Tremont St., Boston, Mass., Feb. 22, 1910.

Sir: For a number of years I have been a subscriber to your valued paper and each week, as the mail man places it in my hand, I delve into it with the avidity of a youngster into a Christmas box. Many are the vexatious problems that have been solved by the light of some other man's experiences as recorded in its pages, and to my mind the most interesting section of the paper is that part devoted to "Letters to the Editor."

I always turn to this part prepared to absorb some useful bit, and, being interested in all that pertains to the use and distribution of water, I noted with pleasure a column article in my last copy (Feb. 17) which, from a hasty glance, seemed full of "something" from the amount of figures in evidence, and it was with especial interest that I noted it was from the pen of a local engineer who at times signs himself M.I.C.E.I., whatever that may be, and M.R.G.S.

But to return to this weighty problem (for a school boy) which this hydraulic engineer propounds. The gentleman says first that he has a vertical lift of 55 ft., which, from my knowledge of the location, I should say is about 10 ft. more than there actually is, but we will concede that 55 is correct.

Referring to his letter, we next have 120 ft. of 3-in. iron pipe, then 1,500 ft. of 3-in. wood pipe, a tee and two branches of 3-in. wood pipe of approximately 1,750 ft. each way, making 3,370 ft. of 3-in. main, which, for the sake of round numbers, we will call 3,400 ft.

In addition we have the laterals of ¾-in. pipe ranging from 100 to 500 ft. in length and aggregating 4,000 ft., with 1,800 ft. of ¾-in. hose and the necessary stops and Sprinklers.

We will only take 500 ft. of this ¾-in. pipe into consideration, as this seems to be the maximum unit, and place it at the far end of our distributing system and not worry about the other 3,500 ft. as our friend with the "instinctive genius," so evidently did when he so severely took to task the theory of our illustrious investigators, Eytelwein and others, to whom we have always looked up with a respect akin to reverence.

Without considering the problem in detail but simply to make as bad a case as possible of it we will assume that all of the water is delivered through one branch of the main, which we will take as 3,400 ft., and 20 laterals of ¾-in. pipe each 500 ft., and the stops and sprinklers and 100 ft. of garden hose which, for good measure, we will take as the equivalent of 200 ft. of pipe, making each lateral 700 ft. of ¾-in. pipe.

Unlike our friend who questions the authorities, we will only consider one of these laterals and base our findings on the grounds that if we provide sufficient head to supply 100 gals. per min. into a tank which is elevated enough to provide the head to supply 5 gals. per min. through 700 ft. of the ¾-in. pipe, that we have done all that Trautwine, or Eytelwein, or Molesworth would consider necessary. Using Coffin's tables, based on the Chezy formula, which seems to give values on the side of safety, and summing up, we find what follows: First in the 3-in. pipe we have 3.5 ft. head per 100 or 119.00 ft. total. To this we add the initial lift of 55 ft., making 174. The head per 100 ft. of ¾-in. pipe we find is 7.6 ft. when supplying 5 gals. per min., the maximum noted, so 700 ft. will add 53.2 ft. head, maximum, which will bring our total up to 229.2 to deliver 100 gals. per min. to 20 sprinklers at the extreme end of our system.

A hundred gallons weighs 833 lbs. and lifting it through 229.2 ft. is approximately 190,000 ft.-lbs. per min., which, divided by 33,000, gives us roughly 6 HP.

This as noted as a maximum case, a detailed study of the layout would result in a much reduced power requirement, but I think this is sufficient to establish the fact that the theories and formula given us by the famous Weisbach, Chezy, Eytelwein and others are not so very far from the mark after all, provided we know how to use the information which they place at our disposal and for which I, for one, am deeply grateful.

I am prepared to acknowledge the truth of Mr. Fuller's statement, that there is still a lot to learn about the flow of water, but as Merriman and others have well said, a difference of 2 to 10% is of no consequence when the commercial sizes of your pipes will make superfluous any greater refinement, and the information available is certainly sufficient for such a case as this.

Trusting that I have succeeded, in a measure, in establishing a defence for the knowledge and theory of the illustrious founders of our science and that "instinctive genius" (in the shape of some pump catalog) may always serve as well as it did in this case, I am,

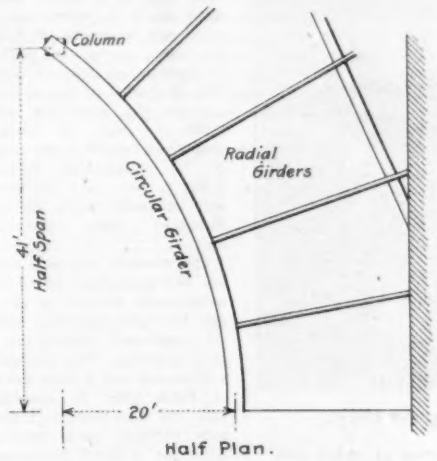
Very truly yours,

M. M. Caldwell.

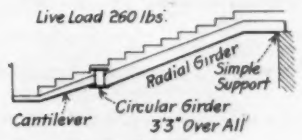
Barton-Caldwell Co., Engineers and Contractors.
Savage-Scofield Bldg., Tacoma, Wash., Feb. 27, 1910.

Problem of a Circular Girder with Torsion Bracing.

Sir: Could any of your readers help me in handling the solution of the structural problem enclosed herewith? It is a large circular girder the twisting moment on which is taken up by the radials (not constrained in any way). The difficulty is apparently in finding the true reactions at the several points of support. Two such girders have already been made and installed in



Half Plan.



Cross Section.

one of the largest theaters here. Possibly this treatment of balconies would interest engineers on your side. The idea is to omit all columns in the auditorium and present an unobstructed view.

You will note that the straight span is 84 ft. and the depth is limited to 3 ft.

An early reply would be esteemed a great favor.

G. S. Yates.

135 Humber Road, Blackheath, London, Eng., Jan. 17, 1910.

[This problem is not found in the text-books, and as it involves elastic analysis it should invite the talents of those mathematically inclined.

We assume that the ends of the circular girder as well as of the radials are to be considered simply supported. If there were but one radial, say the middle one, the problem would be statical, as the reactions at the three points of support would have to give a resultant in line of the load resultant, and the bending and twisting moments would follow from the reactions. With more than one radial, there are supernumerary supports, and the reactions therefore depend on the relative deflections. Presumably it would be sufficient to analyze for full uniform live-load, though it is not certain off-hand that this would give maximum stresses at all points.—Ed.]

A Bill to Make Civil Engineering a Close Profession in the State of New York.

Sir: The enclosed bill recently introduced into the Assembly of the State by the Hon. E. J. Lyons Raldiris of the 35th N. Y. District, has been handed to me by some legal friends, members of both houses, who ask what is the opinion of engineers on the subject. The bill, as you note, makes of engineering a profession instead of an "occupation."

I looked in vain this afternoon for reference to it in your columns, and am led, therefore, to inquire whether your silence is intentional or accidental. Can it be possible that a matter like this is of less importance to your readers than a slight variation in the method of mixing concrete or striking a highway bridge center?

Or is an "occupation" whose heads, like our distinguished friends Col. Goethals, Gen. Wm. Barclay Parsons, Hon. John A. Bensel, the veterans, Hunt, Bogert, Samuel Rea, Nelson P. Lewis and State Engineer Williams, are called upon from time to time to preside over enterprises expending from five to four hundred millions of dollars, of so little importance to the community that its representatives are deemed to be still as insignificant in the public estimation as it was a half century ago?

Is it not due those of us who read your journal that some account and possibly some support for such a measure be forthcoming?

If it has faults, why not suggest corrections at this time when they can be adopted and the whole tone and standing of the "occupation" raised?

Respectfully yours,

Walter G. Eliot, C. E.

Long Island City, N. Y., March 5, 1910.

[We printed a brief statement regarding the introduction of the bill to which our correspondent refers, in our issue of Feb. 24, page 233. The mere introduction of a bill into a legislative assembly means so little, ordinarily, that we did not attach much importance to the matter. If, however, there is any prospect whatever of the bill's enactment, or of any action being taken of the sort to which this bill looks, then engineering organizations throughout the state should at once take measures to let their opinions upon the measure be known at Albany.

The position of Engineering News upon the general proposition to restrict by law the practice of the engineering profession his been so definitely expressed in the past that it seems unnecessary to repeat it here. We may say, however, that from such examination as we have given to the proposed bill, it seems to us one to which a very large proportion of the engineering profession would be strongly opposed. It does not seem worth while to take the space to criticize the bill in detail, but we may say that the proposal to place the engineering profession, and admission thereto, in any manner under the control of the Board of Regents of the University of the State of New York should be strongly opposed.—Ed.]

Friction in Delivery Pipe Lines from Hydraulic Dredges.

Sir: On page 286 of your issue of March 10, you seem still uncertain of my correction of the loss of head in the Panama dredge plant due to pipe friction. I wish to emphatically state that the loss is 2 to 3 ft. per 1,000-ft. length and not 2 to 3 ft. per 100-ft. length.

I have pumped through level pipe 10,760 ft., with a discharge gage pressure at the pump of only 30 lbs., and delivered 100,000 cu. yds. per month of solid material under said conditions and accompanied by nine times this volume of water.

If the Panama figures were correct, I should have pumped against a friction head alone of 200 to 260 ft. with a gage pressure of 100 to 125 lbs. plus the velocity flow head.

Yours very truly,

H. S. Wood,
M. Am. Soc. C. E.

1825 Park Row Bldg., New York, March 10, 1910.

Notes and Queries.

In regard to the high snow load mentioned by Prof. A. E. Winslow in describing a roof collapse at Northfield, Vt., p. 290 of our last issue, we have the following further particulars about this snow load from Prof. Winslow in answer to our inquiry:

Our snowfall this year has been exceedingly large, amounting to some 80 ins. Under periodic thaws and rains this 80 ins. had become compacted and melted until at the time of failure there was on the roof about 30 ins. If we figure this at 15 lbs. per cu. ft., which I believe is small, we should have 38 lbs. per sq. ft. from snow load alone. In addition a slow, gentle rain had been falling all the previous night and had thoroughly saturated this snow with water. I am confident that this snow would retain a weight of water for a short period equal to 30% of its own weight. We must bear in mind that a large part of the roof was also covered underneath the snow with a snow ice which weighs more than snow and assists in retaining the water.

A STREET-RAILWAY GARBAGE CAR is to be used by the Chicago Railways Co., on certain North and West Side lines in Chicago to test the desirability of removing city wastes over street-car lines. The car is a trailer, built by The Arthur Koppel Co.; it is of all steel construction, is 37 ft. long and has a carrying capacity of 20 cu. yds. in its three sections. These sections are independent and are manually dumped. It is intended to use this car for transporting construction materials during the day and for garbage at night.

Laying Concrete Under Water on the Detroit River Tunnel.*

By OLAF HOFF,† M. Am. Soc. C. E.

When reviewing the great number of subaqueous structures as designed and constructed by engineers in the past, one cannot fail to note the hesitancy and diffidence, with which they have approached the problem of depositing concrete under water, and how they apparently have resorted to this expedient, by way of compromise, where none other seemed available, except at an unjustifiable expense.

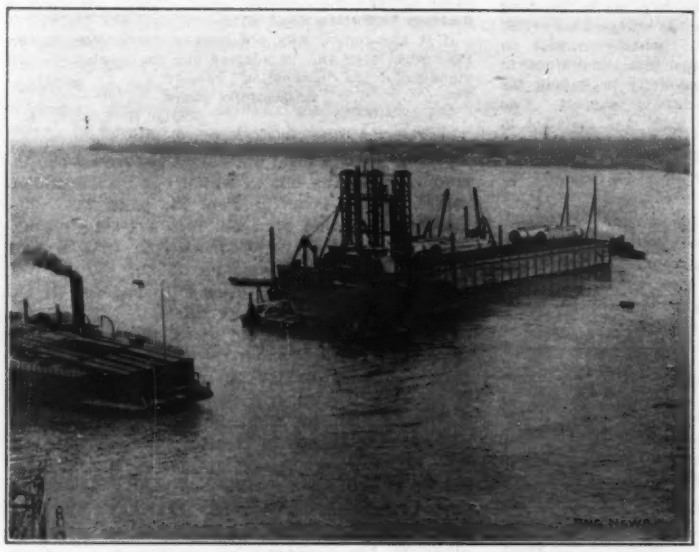


FIG. 1. VIEW OF TREMIE SCOW IN MIDDLE OF RIVER.

The reasons are obvious; the chief difficulty among the many presenting themselves, being to convey the mass of semi-fluid concrete mixture through the water to its place of deposit in such a manner as to preserve the mixture intact and prevent segregation of its integral parts, which would leave only an inert mass of aggregate. As a consequence the application of the method has been very limited, and the experience gained equally so.

Various expedients and devices have been adopted for solving the problem, the principal ones being the use of bags, drop bottom buckets and tremies, all subject to objections peculiar to each.

Laying concrete under water by means of bags involves the use of divers in placing the bags, and is accordingly cumbersome, slow, and expensive; the results are not wholly satisfactory and the method should be classed as obsolete.

Neither is the use of drop bottom buckets all that could be desired; even with the greatest care it is not possible to prevent the mass from dropping a short distance through the water, which thus set in motion has a tendency to remove the cement from the aggregate and produce a lean concrete in spots, where a uniform and homogeneous structure is the ideal sought for. Irregular cleavage lines in the concrete are likely to occur, which objection is also applicable to the use of bags.

The depositing of concrete by means of tremies has heretofore presented difficulties which have not always produced satisfactory results. A tremie is nothing more or less than a long tube reaching from the place where the concrete is to be deposited, to the surface of the water above, its upper end being provided with a hopper for receiving the mixture; as fast as the concrete escapes at the lower end of the tube it is replenished at the upper end, thus flowing in a continuous stream.

Theoretically this is the ideal way of laying concrete under water, but when reduced to practice the object has not proved so easy of accomplishment. The difficulty has principally been to control the flow of the concrete through the tube and prevent the water from the outside to rush into the tube from below, thus washing the concrete and separating the cement from the aggregate, losing the charge; the concrete would be liable to run out either too fast or too slow. Generally the concrete has been deposited in layers of various thicknesses, governed by the position of the mouth of the tremie with reference to that of the layer below. This also of necessity results in a certain amount of motion of the concrete through the water, with attending loss of cement.

These difficulties were successfully overcome in the construction of the Detroit River Tunnel, more than 100,000 cu. yds. of concrete having been deposited in water by means of tremies; the operation extending over a period of part of three seasons, 1907, 1908 and 1909.

In order to describe the methods used and convey a correct understanding of same, it will first be necessary to give a short description of the tunnel itself and more particularly the subaqueous part of same.

This tunnel* is of double track, built for the use of the New York Central System of Railroad lines, passing under the Detroit River and connecting the City of Detroit, Mich, with the town of Windsor, Canada. It is built as two separate tubes with a center wall between each with an overhead clearance of 18 ft. above top of rail, and a length of 8,360 ft. from portal to portal. It consists of three sections, the westerly approach tunnel on the American side 2,135 ft. long, the section under the Detroit River proper, or subaqueous section, 2,625 ft. long, and the easterly approach tunnel on the Canadian side 3,600 ft. long.

The westerly approach tunnel and adjoining end of the subaqueous section is on a 2% gradient and the easterly approach tunnel on a 1½% gradient. The subaqueous section has a level grade of some 1,000 ft. merging into the approaching gradients through long vertical curves at either end. It also has a short horizontal curve of 2° curvature at the westerly end. The portals are approached through long open cuts at both ends of the tunnel.

The approach tunnels on both sides of the river were driven through a formation of plastic blue clay by means of shields. The same clay formation extends across the river and overlies bed rock which is found at a depth of some 10 to 30 ft. below the tunnel structure.

The subaqueous section was built on a unique and novel plan never heretofore used, which proved highly successful both as to cost, speed of construction and safety. It consisted in excavating a trench in the bottom of the river, of the required width and depth, into which steel tubes were sunk; these were thereupon encased in concrete laid under water, pumped out and then lined with concrete on the inside. The whole operation proved to be very simple and easy of execution.

The top of the tunnel structure generally follows the bottom of the river; at the middle it even projects a few feet above the bottom; at the deepest part it is 41 ft. 9 ins. below the surface. The bottom of the structure at this point is about 74 ft. below the surface of the river.

The excavation of the trench was done with an ordinary clam shell dredge, well in advance of the sinking of the tubes. The tubes were circular in form with a diameter of 23 ft. 4 ins. and were arranged and sunk in pairs, one tube for each track; they were built of ⅜-in. steel plates. They were spaced 3 ft. apart between the shells and reinforced on the outside by a series of transverse steel partitions or diaphrams, 12 ft. apart. These diaphrams extended all around the tubes and were approximately of rectangular shape with an extreme depth of 30 ft. 4 in. and extreme width of 55 ft. 8 ins.; thus extending beyond the steel shell 3 ft. at the bottom, 3 ft. on the sides and 4 ft. on the top of the tubes. They were strengthened by means of double angle irons riveted along the edges; wooden sheathing running lengthwise of the tubes was bolted along the vertical edges of the diaphrams. The tubes were built in lengths of 262 ft. 6 ins. and were provided with temporary wooden bulkheads at the ends so that they would float when launched.

For the purpose of sinking the tubes they were equipped with four buoyancy cylinders attached on top, which enabled the tubes when filled with water to be kept in suspension at any point, lowered to the final resting place by means of floating derricks and connected up with the tubes already sunk.

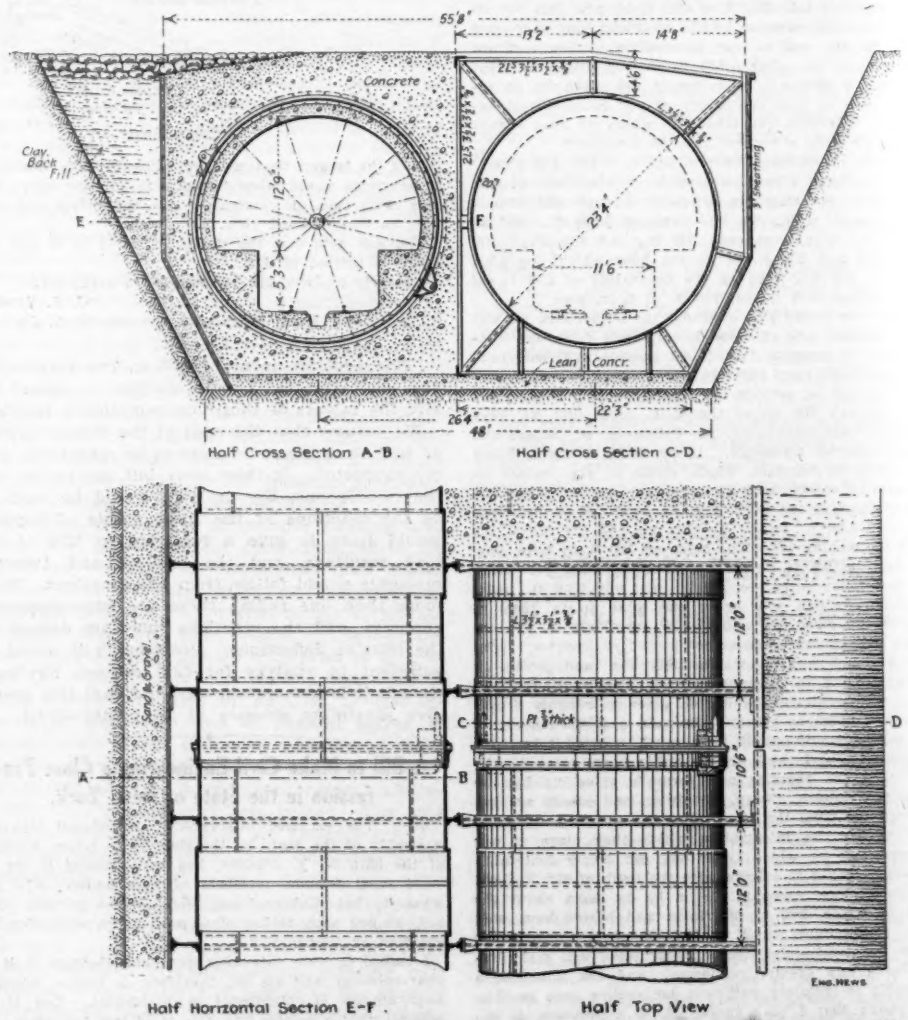


FIG. 2. SECTION THROUGH SUBAQUEOUS PORTION OF THE DETROIT RIVER TUNNEL.

*Engineering News, Feb. 15, 1906, p. 182.

*Paper read at the annual meeting of the National Association of Cement Users, Chicago, Ill., Feb. 21-26, 1910.

†Consulting Engineer, New York.

Before sinking a platform was built in the bottom of trench at the proper level to temporarily support the ends of the tubes. When in their final position the tubes would underneath be from 5 to 7 ft. from the bottom of the trench depending upon how near the correct level this was excavated. The diaphrams crosswise of the tubes and the wooden sheathing on the sides parallel with the tubes, would then present in exterior view a series of pockets open at the top and bottom, but with enclosed sides and ends. Into these pockets concrete was poured by means of three tremies, one placed in the middle between the two tubes and one on the outside of each tube, between the steel shell and the wooden sheathing.

The mode of proceedure in placing the concrete was generally, first, to concrete in the bottom to the under side of the diaphrams, thus sealing the pockets and affording support for the tubes. The buoyancy cylinders holding the tubes in suspension could then be removed, and each pocket filled with concrete in one continuous operation, forming a monolithic mass of a thickness of 3 ft. on the sides of and between the tubes, 4 ft. to 4 ft. 6 ins. on top of the tubes, and a thickness of 5 to 7 ft. underneath the tubes, varying with the irregularity of the bottom.

Generally every other tube length was provided with an extra strong bulkhead at the extreme end, capable of resisting the full hydrostatic pressure when the tubes were pumped out, in order to give access to the interior and permit the placing of the concrete lining.

The equipment used for the purpose of placing the subaqueous concrete consisted of a "tremie scow," so-called, especially designed and built for the purpose. This scow was 35 ft. in width, 155 ft. in length and 9 ft. 9 ins. in depth with a free board of about 4 ft. It was equipped with 4 spuds, one in each corner, of 20 ins. square, 90 ft. long Oregon fir timbers, and necessary spud hoists. The object of these spuds was to hold the scow steady during concreting, and prevent any rocking motions caused by waves, or the wash from passing steamers. The scow was further held in position against the current by anchors and was equipped with deck hoists for handling. On one side of the scow was built three towers 82 ft. high above the deck, one for each tremie, the front of these towers served the purpose of leaders (similar to those of a pile driver) for the tremie pipes, which could be hoisted clear out of the water or lowered down to the bottom of the trench, as required. There were three concrete mixers, one for the middle tremie with a capacity of about 30 cu. ft. to the batch, and two concrete mixers one for each of the side tremies with a capacity of about 20 cu. ft. to the batch. The equipment further consisted of an air compressor, a dynamo and an electric conveyor for conveying cement to the charging floor from scows alongside the tremie scow, three hoisting engines for the tremies, two large derricks with hoisting engines for unloading gravel, and a 150-HP. boiler.

Gravel was used for mixing the concrete in preference to broken stone; it was of size grading from that of small walnuts downwards. Mixed with approximately the proper amount of sand it was found and pumped out of the river near Port Huron, Mich., some 60 miles away from the tunnel site and transported in boats or barges down the Detroit River to the tunnel. The tremie scow was designed particularly for the purpose of handling and mixing this gravel as cheaply as possible. The gravel was unloaded directly from the boats to the tremie scow and used up about as fast as unloaded. To this end the tremie scow was equipped with two heavy derricks located about at the quarter points of the scow on the opposite side to that of the tremie towers. These derricks were operated by large hoisting engines located on the deck of the scow, the gravel being unloaded by means of clam shell buckets and discharged into two hoppers located 32 ft. above the deck of the scow, immediately behind the towers. From these hoppers the gravel would fall over inclined screens into receiving bins, being thus screened by gravity, the sand running off into one bin and the gravel into another. There was one sand bin and one gravel bin for each tremie. The bins for the center tremie were of about twice the capacity of the others, because this tremie had to deposit approximately twice as much concrete. The screens below the unloading hoppers were four in number, two for each hopper, inclined in opposite directions so that the gravel would feed one-half to the bin of the side tremie, and one-half to that of the center tremie. The sand and gravel bins were placed a few feet above the charging floor which was located 11 ft. above the deck of the scow, and was on a level with the top of the charging hopper of the concrete mixers. Through gates in the bottom of the bins the proper amount of gravel and sand could be drawn into the charging hoppers. This floor was large enough to hold a sufficient quantity of cement for one pocket. The water tank was also located on this floor, from which water was piped to the mixers.

The concrete mixers were placed directly on the deck and when tilted would discharge into self-dumping buckets, placed in the hull of the scow directly in front of the mixers; these buckets could be hoisted up to any point where the receiving hoppers of the tremies might happen to be located and discharge their contents into same.

The total amount of concrete in one pocket was about 342 cu. yds., of which approximately one-half had to be deposited through the center tremie and one-fourth through each of the side tremies.

Each tremie consisted of a 12-in. diameter spiral riveted steel pipe of No. 10 metal 80 ft. long made in 20-ft. lengths provided with external flanges for bolting up. The upper end of the tremie pipe was suspended from a frame, to which was attached a hopper for charging the tremie, the hoppers with frames running between guides attached to the front of the before-mentioned towers. The tremie pipes, hoppers and all could be raised and lowered by means of steel hoisting ropes leading over sheaves at the top of the scow. The buckets in the hold of the scow upon receiving a charge from the concrete mixers were hoisted up inside the towers until they reached the tremie hoppers, which would engage them and trip them forward, discharging their contents into the hoppers; then they would reverse and go down, to their place in the hold of the scow. These buckets ran between guides located inside the towers immediately in the rear of the guides of the tremie hoppers. The concrete in passing from a mixer into the bucket would discharge over an apron which the bucket would trip forward every time it descended and trip back out of the way when hoisted up. The tremie hoppers were provided with a small platform on the outside and a railing around same where a man could stand and watch the concrete in the tremie, whether it was running out too fast or too slow, and give signals accordingly to the engineer who ran the corresponding engine.

The working force for operating the tremie scow when the process of concreting was going on, was 32 men, on an average.

The operation was as follows: The tremie scow was anchored across the tunnel tubes in the trench, so that the tremies when lowered into place would come in the middle of a pocket, as already stated, one tremie between the tubes and one on the outside of each tube between the steel shell and the sheathing. The spuds were then lowered to the bottom and forced down sufficiently to take up load from the scow and prevent any rocking motions. The three tremie pipes were lowered

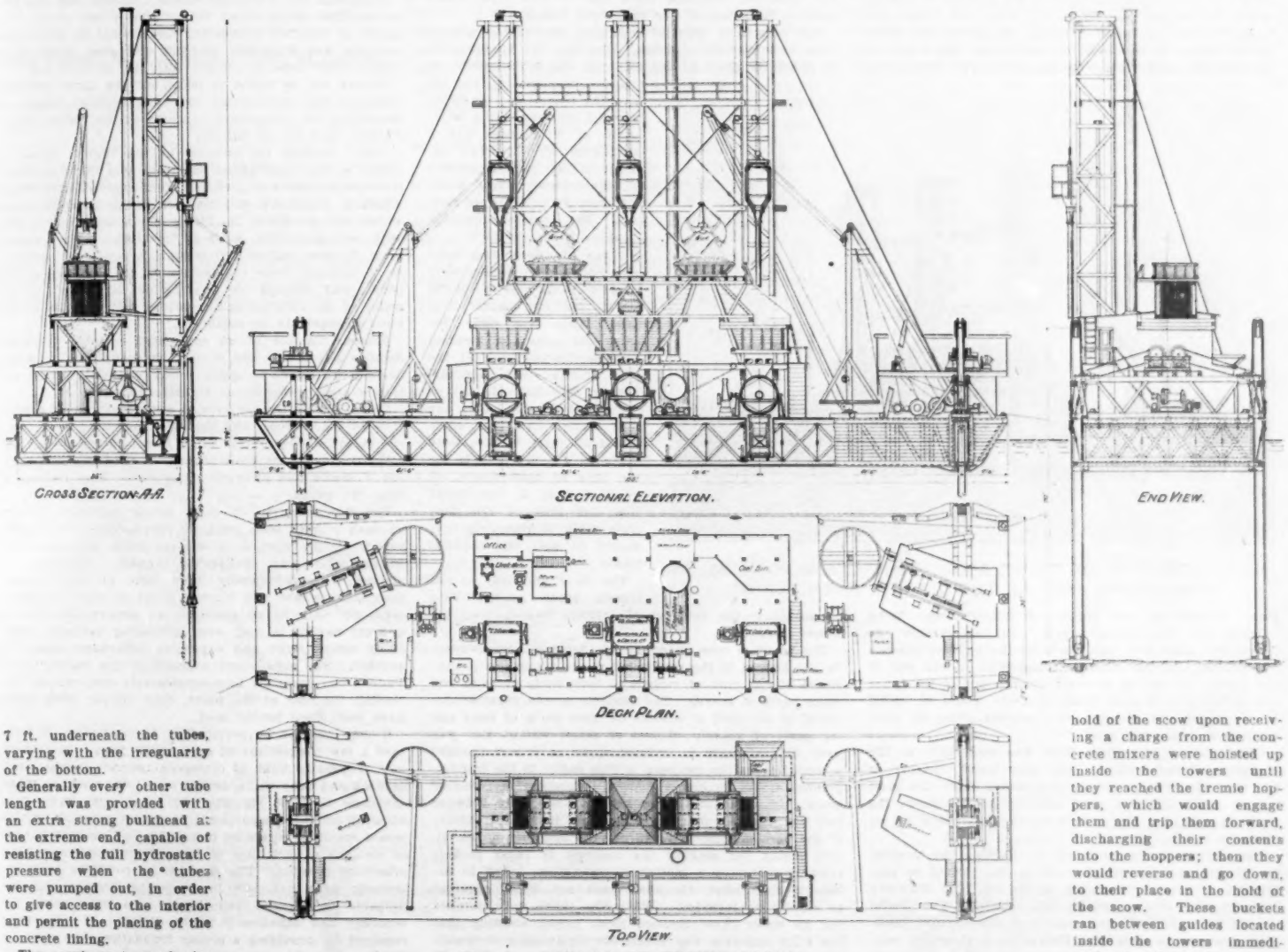


FIG. 3. DETAILS OF TREMIE SCOW.

into position until their lower ends rested on the bottom of the trench; the water inside of the tremie tubes would of course be at the same level with the water outside. Meanwhile the boat loaded with gravel would be placed alongside the tremie scow on the opposite side. The gravel with its mixture of sand would then be unloaded by means of the clam shells and derricks, and dropped into the hoppers previously described, falling over the inclined screens, the sand and gravel shooting off into their respective bins, from which they would in turn be drawn, as required, into the upper hoppers of the concrete mixers, cement added, and the charge shot into the mixer, where the necessary water was added in the usual way.

A wadding of cement sacks was at first placed in each tremie on top of the water to prevent the concrete from dropping through while filling the pipe. A batch of concrete was discharged from the mixer into the bucket in the hold of the scow and hoisted up until a projecting arm on the receiving hopper of the tremie would cause the bucket to tilt forward and discharge the contents into the tremie hopper and on top of the wadding, the bucket immediately returning to its original place to receive a new charge, already in the process of mixing. When this hopper was about half filled, the tremie and hopper would be raised a trifle, permitting the water in the tremie to escape at the bottom as the weight of the concrete pushed the wadding downwards through the pipe. Meanwhile fresh batches of concrete were being dumped into the tremie hopper. In this manner the tremie was filled with concrete until the wadding reached the bottom and the concrete commenced to run out of the pipes. As fast as the concrete ran out at the lower end of the tremie pipe, fresh concrete would be added at the upper end of same, this process going on until the whole pocket was filled.

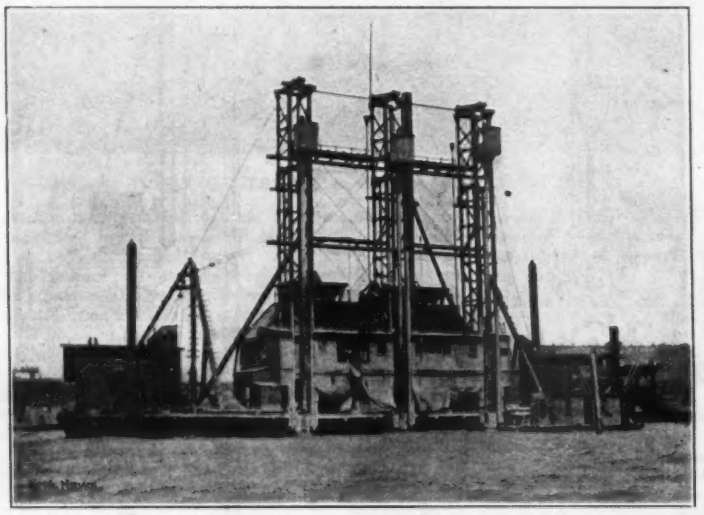


FIG. 4. NEAR VIEW OF TREMIE SCOW, CONCRETE DEPOSITING ON SUBAQUEOUS PART OF THE DETROIT RIVER TUNNEL.

This wadding of cement bags was used only at the beginning of the work. It was soon found that one or two very dry batches of concrete would serve the same purpose, and this was used practically throughout the work in charging the tremie at the beginning of an operation.

The concrete except as noted in charging the tremies, was mixed very wet, much more so than would be permissible in concrete deposited in the air. No difficulty however, was experienced on this account. The gravel showed no tendency to segregate from the mixture, probably because the mass was always in a slow and uniform motion, and when it reached its place of deposit the mass would be under a heavy hydrostatic pressure, that may have had the effect in connection with the loss of weight on account of buoyancy, of making segregation more difficult.

It should be particularly noted that the mouth of the tremie was always buried in the concrete from 2 to 5 ft., forming an effective seal which at all time prevented the outside water from forcing itself into the tremie. It was the duty of the inspector on the platform of the tremie hopper to always be on the lookout that the tremie was full of concrete. If the concrete showed a tendency to run out too fast he would signal the hoisting engineer to lower the tremie and thus choke off the flow; if the concrete did not flow fast enough he would order the tremie raised until the concrete would flow more rapidly.

It is a fact, that after a week or so, when the men on the concrete scow had become thoroughly familiar with their duties not a single charge was lost in depositing more than 100,000 cu. yds. of concrete. The concrete when deposited would take an exceedingly flat slope, in fact practically seek its own level. Occasionally a small mound would be built up around the mouth of the tremie, but the least agitation of same would cause this mound to spread out to a practically level surface. As soon as a pocket was finished the concrete scow was shifted to the next one. No pocket was ever started unless the necessary materials of sand, gravel and cement were on hand to complete it.

In depositing the concrete, divers were employed for inspecting the progress of the work, and report when a pocket was completed.

The time required for filling one pocket usually ran from four to seven hours. The largest amount of concrete placed by the tremie scow per day was three pockets or 1,025 cu. yds., working 16 hours. This includes the time required for replacing the gravel boats, alongside the tremie scow. These boats generally held enough gravel for one pocket. The amount of concrete that could be placed depended mostly upon the supply of gravel. Usually three pockets were concreted in two days, that is one pocket one day and two pockets the next.

As previously stated the bottom of the trench was first filled with concrete to the under side of the diaphrams; this generally required from four to five days, sometimes a little longer, for each tube length.

The length of time of mixing a batch was usually from two to three minutes. The time for the concrete to reach its place of deposit from the mixer would, of course, vary greatly, but the average time was probably about 8 minutes with a minimum of 5 minutes and a maximum of 15. The velocity of the flow of concrete in the tremies would average from 14 to 15 ft. per minute. The extremes probably running from 7 to 23 ft.

When the work first commenced the side tremies were made of 10-in. pipe as against 12-in. for the center tremie. This was done because the amount of concrete passing through each of the side tremies was approximately only half of that of the center tremie. After the first section had been completed all three tremies were made 12 ins. in diameter for the sake of convenience, as by that time it was found that the flow of the concrete could be absolutely regulated to suit the requirements.

The wear and tear of the tremie pipes proved very insignificant, the full set of tremies having been renewed only once.

The concrete was mixed in the following proportions: In the bottom of the trench below the diaphrams it consisted of one part of cement to four parts of sand and eight parts of gravel. The concrete in the pockets consisted of one part of cement to three parts of sand and six parts of gravel. Gravel of small walnut size was used in preference to crushed stone as it was thought it would cause the concrete to flow easier in the tremies, besides gravel makes a denser concrete than crushed stone. In some of the pockets at the joints between two sections the concrete was made in the proportion of one part of cement to two of sand and four of gravel. The reason for making the concrete in these pockets richer was simply a matter of precaution, taken to ensure a tight joint, the steel work not fitting together as closely as intended. When the tubes were pumped out no water came through these joints, showing that the 1:2:4 concrete was practically impervious to water, although subject to a hydrostatic pressure of about 25 lbs. per sq. in.

For the purpose of determining the quality of the concrete, 6-in. cores were taken out by means of a core drill for the full height of the center wall between steel tubes. These cores show a remarkable degree of uniformity of the concrete and of high quality both as to density and strength; in fact a better grade of concrete was obtained than would be possible in the open air. It should be noted in this connection that this concrete was compressed and set up under a hydrostatic pressure of from 16 to 30 lbs. per sq. in., at the top and bottom of a pocket respectively. The crushing strength of this concrete when two years old, ran from about 2,800 lbs. per sq. in. minimum, to 4,000 lbs. per sq. in. maximum for a mixture 1:3:6, according to tests made upon cores taken from the center wall.

A word should be said with respect to the time of setting or hardening of the concrete; this is, to be sure, a debatable subject. However, the consensus of opinion among the engineers connected with the work, including the writer, based upon such tests as could be made by divers, seemed to be that the initial set was acquired in about 10 hours, after the concrete was deposited, and the final set in 20 hours; after 40 hours the concrete was very hard, so that it would ring when struck with an iron bar.

Regarding the matter of laitance, hardly any was observed that would affect the quality of the work; this might be expected considering the manner in which the concrete was deposited, whereby the great mass of it would never come in contact with the water at all.

It may not be amiss to point out the three essential elements that contributed to the successful results in depositing the subaqueous concrete of the Detroit River Tunnel; they are as follows:

First, dividing the exterior of the tunnel tubes, by means of the longitudinal sheathing and the diaphrams, into compartments or pockets. This produced still water, which is absolutely essential for laying concrete under water, and permitted the filling of one pocket at a time with one monolithic mass of concrete. This arrangement further limited the lateral flow of the concrete, as it emerged from the tremie, to the confines of the pocket and reduced the washing out of cement by the water to an absolute minimum; in fact the loss of cement appeared to be negligible.

Second, the use of an equipment complete in every detail and equal to any demand made upon it, more especially an active or quick acting rig for handling the tremie pipes promptly as occasion required.

Third, mixing the concrete so wet, that it would readily flow in the tremies, and the flow controlled by keeping the mouth of the tremie at all times buried in the concrete at a sufficient depth thereby at the same time keeping it sealed and preventing the water from rushing in from the outside.

The demonstration of these highly successful results on such a large scale suggests possibilities of the application of this method to various kinds of engineering works, other than subaqueous tunnels. Numerous instances will undoubtedly from time to time present themselves where this method could be used to advantage, not only as an expedient of construction, but at a great saving in cost over prevailing methods, especially where large and expensive cofferdams would be avoided. The subaqueous concrete of the Detroit River Tunnel was deposited at a considerably less expense, including the cost of the plant, than similar work could have been done for on land.

It may perhaps be permissible, in conclusion, to venture a few suggestions of such applications. Structures, now frequently built of cyclopean concrete blocks, such as dock and quay walls, breakwaters, etc., could in many instances be built "in situ" by using steel forms constructed on the compartment or pocket principle, which would result in obtaining monolithic and massive blocks, or sections of structure of far greater magnitude, than otherwise possible. The steel forms could be built extremely light and left in place, or heavier and detachable to permit their being used over again, as economy and expediency might dictate. If piles were required for providing a proper foundation they could be driven after the excavation was done to the required level, the forms set over them and then imbedding them in the concrete.

Similarly drydocks, light-house foundations and bridge

COMPARATIVE STRENGTH OF 1 : 3 : 6 CONCRETE LAID IN AIR AND IN WATER.

Concrete laid under water.

Cyl. No.	Date made.	Weight per cu. ft.	Area of core, sq. in.	Depth at which cores were taken, ft.	Strength in lbs. per sq. in.	Age.	
U-16-4	3-24-07	155.1	.....	....	1,451	2 years	Deposited by upper side tremie.
U-16-6	"	142.4	.....	....	1,568	"	
C1-17-15	3-25-07	153.3	.....	....	3,273	"	Deposited by center tremie.
C1-17-16	"	155.0	.....	....	2,884	"	
C1-17-20	"	145.9	.....	....	2,740	"	
C1-17-21	"	155.3	.....	....	4,060	"	
				Average	2,663	"	

Concrete in retaining wall:

4	4-28-08	128.1	19.635	....	1,201	16 mos.
7	"	149.8	"	4.4	1,849	"
18	"	154.0	"	12.1	2,659	"
21	"	154.1	"	14.9	2,396	"
23	"	158.8	"	16.4	2,379	"
30	3-31-08	153.4	"	20.8	2,100	17 mos.
				Average	2,097	

piers could be constructed, always of course depending upon local conditions and circumstances as to the applicability of the method.

[We have received from Mr. Hoff, the appended communication, showing some later tests on the concrete taken from the walls of the tunnel.—Ed.]

Sir: Since writing the paper on "Laying Concrete under Water" I have through the courtesy of Mr. B. Douglas, Tunnel Engineer of the Detroit River Tunnel Co., received some tests of cores of the concrete deposited under water by tremies, which tests are given below. Why the tests should show better results with the center tremie than the side tremie I am unable to explain at the present time. The cores were cylindrical and a little less than 5 ins. in diameter. Mr. Douglas also had some cores taken with the same drill from the north retaining wall of the westerly open cut. This wall was built of the same materials and in the same proportions (1:3:6) as the subaqueous concrete. These tests are abstracted in the table on the opposite page and afford an interesting comparison between the concrete laid in air and that laid under water.

Yours truly, Olaff Hoff.

Partial Failure of a Concrete Dam at Austin, Pa.

During the heavy floods which were prevalent throughout the eastern section of this country in the last part of January of this year, a number of sensational accounts appeared in press dispatches describing the failure of a concrete dam across Freeman's Run, in Austin, a town on the Buffalo & Susquehanna R. R., in Potter Co., Pennsylvania. These accounts consisted mainly in descriptions of the impending destruction of the town, which was saved only by the dynamiting of the dam holding back the flood. We have since learned that these reports were exaggerated and have also secured from Mr. T. Chalkley Hatton, M. Am. Soc. C. E., the designing engineer, an account of the trouble. From his notes we have prepared the following description.

The Bayless Pulp & Paper Co., of Binghamton, N. Y., operates a paper mill, securing water for its plant from Freeman's Run, which flows through the town of Austin. The paper mill and a large part of the town are located close to the banks of the creek, as the valley is very narrow and the surrounding hills steep and rugged, rising in a distance of one-half mile to a height of approximately 500 ft. above the level of the creek.

Freeman's Run has a watershed of approximately 35 sq. miles which is quite mountainous, and much of it is covered with a short growth of timber. During the summer and the fall the run-off from the stream is not sufficient to supply the paper mill with water for its purposes. About 11 years ago a small dam was built across this run about a mile above the mill to impound about 25 million gals. This dam was built with a rubble stone core wall, 5 ft. 6 ins. thick on the bottom and 18 ins. on top, with unpacked earth slope on the down-stream side built on a slope of 1:1 and an unpacked slope on the up-stream face of 1½ to 1. The core wall is 20 ft. high and rises 1 ft. above the normal water level in the dam, when the dam is full. It rests upon the top layer of sandstone rock which lies under the entire valley in thin layers. To the eye this dam, when the water is out, looks very weak indeed, but it has successfully withstood the floods of 11 years, during which much of the down-stream slope has been washed away, exposing the core wall several feet in depth for most of its length, which is about 380 ft.

As the business of the paper mill increased, it became necessary to impound a greater volume of water in order to carry operations over low runs of the stream. Mr. Hatton was engaged to design and supervise the construction of the proposed dam, which he located about 800 ft. below the old dam where the width of the valley was about 350 ft. To impound 200,000,000 gals. of water the dam was designed to carry water at a depth of 40 ft. above the normal level of the valley. During the construction, however, the owners directed that this depth be increased to 42 ft. to level of spillway with a 2-ft. 6-in. freeboard, and the accompanying figures show the cross-section as actually built.

The entire valley is underlaid with sandstone rock in horizontal layers running from 8 ins. to 3 ft. thick. Between these layers beds of shale and disintegrated sandstone were located, but there were very few vertical cracks to be observed in the bed of rock. Upon the surface of the rock there was from 5 to 8 ft. of earth and compacted gravel deposited from the washings of the side hills. This was so well cemented together that it was removed with the utmost difficulty, and but little water filtered through it into the foundation trench during construction.

In preparing the foundation all loose rock was removed and the concrete only started after a solid stratum of at least 2 ft. thick was encountered. The surface of the rock was well washed and grouted. A cut-off wall 4 ft. thick and 4 ft. deep was built, as shown upon plan (Fig. 1), and in every case this cut-off wall was carried down to good rock. In order to rein-

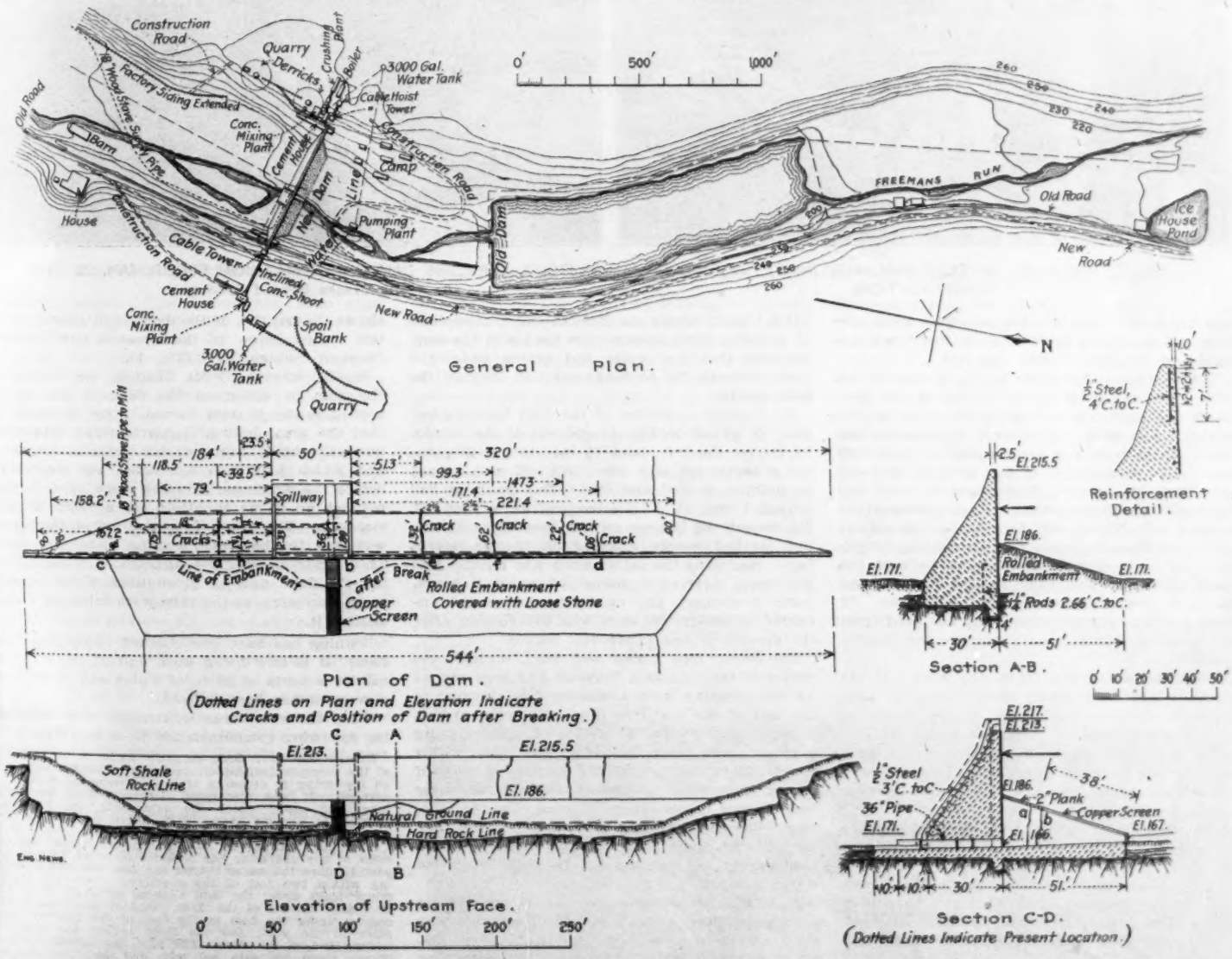


FIG. 1. GENERAL PLAN AND DETAILS OF CONCRETE DAM FOR THE BAYLESS PULP AND PAPER CO., AUSTIN, PA.

force the dam, twisted steel rods 1¼ ins. in diameter and 25 ft. long were built into the wall vertically 5 ft. inside of the up-stream face. Holes were drilled into the foundation rock from 5 to 8 ft. deep, and 2.66 ft. between centers and the steel rods with expansion bolt heads were placed into these holes, which were then grouted.

Upon each side of the spillway a pilaster was built which was reinforced by ½-in. steel rods to prevent cracking. The top 12 ft. of the dam was reinforced with ½-in. steel rods spaced 2 ft. vertically and 4 ft. horizontally to prevent cracking. Against the up-stream face of the dam an earth embankment was laid at a slope of 3:1 and reached to within 27 ft. of the normal water level at the up-stream face of the dam. This embankment was composed of disintegrated shale, clay and some loam, free from large stones, and was carefully compacted by grooved rollers in 6 to 8-in. layers, the work being carefully and well done.

The dam was composed of cyclopean concrete, with large quarry stones, from ½ to 2 cu. yd. size, embedded firmly in wet concrete. These stones were placed so as to break joints, both as headers and stretchers, and surrounded with not less than 6 ins. of concrete, generally much more. In every case the concrete was built in sections, stepped up as shown in Fig. 2, and the steps dove-tailed both horizontally and vertically. In building into the side hills great care was used in getting down to good firm rock foundation before any concrete was laid.

The material for building the dam was secured from quarries opened at either end of the dam, where duplicate crushers and mixing plants were located. The sand was secured by crushing the sandstone with rolls and screening through sand pans. The composition of the concrete was one part Portland cement, three parts of sand and six parts of broken stone. Each shipment of cement, as received, was tested upon the works by the resident engineer, who also made numerous tests to ascertain the difference between the tensile strength when using washed bar sand and the sand secured from crushing the stone. In every case the mixture containing the sand from the crushed stone gave the greater tensile strength.

The concrete was handled in two ways. At the two ends it was run down chutes upon the dam, and there shoveled into place. In the middle of the valley the cableway stretched across the valley carried the concrete in buckets to the wall, where it was shoveled into place. In every case it was well turned over and mixed after leaving the mechanical mixer.

There was no indication upon the part of anyone connected with the work to slight it in any particular. The work was done by C. J. Britnall & Co., of Binghamton, N. Y., on a percentage plan. This company had a very competent superintendent upon the ground, assisted by good foremen. Therefore the work might be considered first-class.

The dam was begun in May and completed about Dec. 1, 1909. It contained 15,780 cu. yds. of concrete. There were 7,925 cu. yds. of excavation in foundations and 6,360 cu. yds. of embankment, costing, exclusive of engineering, $71,821.48.

When completed there was one small vertical crack, 51.3 ft. to the right of the spillway, shown upon the plan in Fig. 1. This crack extended from the top to the ground level and was about 1/16-in. wide. Later in December another crack showed up 39.5 ft. to the east of the spillway, as shown upon the cut above referred to. This crack was similar in all respects to the other crack, and appeared to be due to contraction, as there was no evidence of a settlement. They could not have been the result of water pressure because up to this time there had been no water in the dam.

During the week of January, 17, 1910, the weather grew warm and some rain fell. The heavy snows of the preceding month were rapidly melting and within three days the dam filled to overflowing, which it was doing on Saturday, Jan. 21. On Sunday afternoon a large slice of the earth forming the eastern hill below the dam dropped down some 8 ft. and partially slid into the valley, and some water came down under the slide, which was evidently coming from behind the dam. Water in large quantities began coming up through the ground from 15 to 50 ft. down-stream from the toe of the dam, showing that the water had gotten under the dam, through the embankment and through the rock strata.

On Monday a section of the dam between "a" and "b" (Plan on Fig. 1) slid out at the bottom 18 ins. at the top about 31 ins., this sliding being a maximum at a joint "h" and running out to nothing at "c" and "d." The crack at "a" opened 4 ins., at "h" 4½ ins. and at "e" and "f" 2½ ins. at the bottom on the down-stream face, but pinched nearly together on the up-stream face. So far as the information was reliable this movement covered a period of about 8 hours, when it stopped, and no further movement appeared, although the dam was overflowing after the movement had apparently ceased.

The 36-in. pipe which was built through the center of the dam as a draw-off had been capped by the company with a wooden cap attached to the bell of the cast-iron pipe with wrought-iron clamps, contrary to the advice of the designing engineer, who recommended a valve cap. This cap being at the foot of the spillway it was, of course, impossible to remove it when the water was wasting in such large volumes over the spillway. The company had so built it because they did not anticipate that the pipe would ever be used except for cleaning out the dam when the water was low.

In order to relieve the pressure on the dam as soon as possible, a small section of concrete was removed, by dynamite, on the right side, just where the dam entered the bank. This opening was made about 4 ft. below the water line and 6 to 8 ft. wide, and dropped the head to 37 f

As the whole town was much alarmed for ar this opening was not sufficient to relieve e pressure, about 7 lbs. of dynamite in a ba of sand was lowered over the spillway unt it rested upon the top of the 36-in. cleanout e. When this dynamite was exploded by mean of a battery, it blew the wooden cap clear of e cleanout pipe and in about 16 hours the n was empty.

It was then observed that portions of the n-bankment had been washed away, some it going out under the dam, but the major por n going out through the 36-in. cleanout pipe, nto which it entered through an 18-in. opening m de in the side walls of the intake chamber mar ed "C-D." This opening clearly indicated the move-ment of the dam down-stream.

It was also observed that the up-stream face of the dam was intact except for the vertical cracks marked on Fig. 1 "Elevation of Up-stream face," and these cracks were not over ½ to ¾-in. wide at the maximum, and usually much less. There was no indication of settlement except that the top of the dam at joint "h" had gone out 13 ins. farther than the bottom of the dam, which indicated some settlement at the toe of the dam at this point.

The dotted lines on Fig. 1 ("Plan of Dam") shows the position of the dam when empty, as do the dotted lines in the cross-section marked "Section through C-D" (Fig. 1).

In the opinion of Mr. Hatton, the failure of the dam to withstand the flood of Jan. 21 is probably due to two causes. One of these is that the great bulk of concrete which had been hurriedly built, some during freezing weather, and which had been completed but six weeks before the maximum pressure came upon it, had not set up so as to attain its ultimate tensile strength. The most important cause, however, was due to the water getting under the dam. This condition was not anticipated when building the dam, and all precautions which seemed to be necessary at the time were taken to guard against it.

Nothing has been done toward reinforcing this dam. It is now being used, and at this writing carries a depth of 36 ft. of water and no farther movement has been noticed.

Since the above was written we have received the following communication from Mr. Hatton:

> Excavations have been recently made to the bottom of the concrete foundations upon the upstream face and no fracturing or crushing of the concrete has been discovered. It was discovered, however, that the rock foundation, upon which the dam rests, slid forward, starting at a point about 12 ft. above the base of the dam on the upstream side.
>
> Since the first sliding of the dam no further movement of any character has occurred although during the past 15 days the water behind the dam has been standing within two feet of the overflow. There are three minor leaks under the dam showing up about 10 or 12 ft. below the toe of the dam. One of these shows as coming under the dam to the east of the spillway, the other to the west, and the third around the extreme eastern end of the dam. The first two appear to discharge about 300 gals. per min. and the other one as

FIG. 2. VIEW OF BAYLESS DAM, AUSTIN, PA., DURING CONSTRUCTION.

FIG. 3. BAYLESS DAM UNDER MAXIMUM FLOOD, JAN. 28, 1910. (Note Cracks Beyond Spillway.)

...h more, making the present total leakage about ... gals. per minute. From the evidence thus far obtained the outward movement of the center of the dam was due to the water getting under the foundation, softening up a stratum of clay or shale lying between two layers of rock, and permitting one layer of rock to slide forward about 18 ins. upon the lower layer.

So far as it is possible to determine the 1¼-in. steel vertical anchor bolts, which had been securely anchored to the foundation stone from 5 to 6 ft. below the bottom of the concrete foundation were not sheared, but moved outward with the rock into which they were anchored.

The water getting under the dam at a depth of 6 ft. below the concrete base exerted a much greater upward pressure than was anticipated when the cross-section was designed and reduced the factor of safety against sliding to an unsafe limit.

A Reinforced-Concrete Arch Highway Bridge in Indiana Wrecked by Erosion of Foundations.

A three-arch reinforced-concrete highway bridge (known as the Pugh's Fork bridge) crossing the Flat Rock River about seven miles from Edinburg, Ind., and three miles from St. Louis Crossing, collapsed on Feb. 28 during a flood of exceptional height. The bridge had been completed about eight months ago and had stood one severe flood, accompanied by an ice jam. The following description of the bridge and the accident has been prepared after personal inspection of the wreck by a member of the editorial staff of Engineering News, and from information furnished by the builders and other parties.

The collapse and fall of this bridge appears to have been due to the undermining of one of the piers by the flood, and does not indicate any defect or disadvantage inherent in concrete arch structures. In fact, under the conditions described below it might be expected that a bridge with steel superstructure would have suffered the same fate; except that perhaps one of the three spans might have been left, since the failure of one arch span involves the loss of adjacent arches due to the unbalanced thrust. This, of course, is conjectural only. While the accident presents some features of interest, it does not necessarily involve any doubt or criticism of concrete arch bridges in general. It is well to explain this definitely at the outset, as the accident may be cited as an argument against bridges of this type by those who advocate other types.

Severe floods, such as have occurred recently in the central states, result usually in the loss and damage of numerous bridges. Few of these receive any mention outside of brief notices in the local papers. In such bridge accidents, the structural design of the bridge is rarely involved directly, and as a rule they indicate such features as insufficient foundations or too restricted a waterway for floods, either in width or height of the openings. Thus, while the failure of the Flat Rock River bridge does not point to the type of bridge being a contributory cause, it does indicate three things: (1) the danger of having changes in the designer's plans ordered by those who are in authority but are not qualified to pass upon such matters; (2) the necessity of careful design and substantial construction of foundations for bridge piers in soft or loose material; (3) the importance of providing ample waterway at flood level, especially in streams where much drift is experienced and where the bed is liable to scour.

When the construction of the Flat Rock River bridge was decided upon, a survey of the site was made by an engineer employed temporarily for the purpose by the County Commissioners (Bartholomew County.) Competitive designs for a bridge were submitted by two bidders. One of these was for a steel girder bridge, with foundations (we understand) very similar to those provided for by the accepted design. This accepted design (for the concrete arch bridge) was submitted by the National Bridge Co., of Indianapolis, Ind. The design was accepted, but beyond this the company had nothing to do with the work. The contract was let at $7,827 to the National Concrete Co., of Indianapolis, which is a subsidiary company, and was the only bidder on this design. We are informed that the County Commissioners had no engineer to supervise the work.

The structural design is shown in Fig. 1, from plans kindly furnished to us by the bridge company. Fig. 2 shows the general elevation of the structure and the character of the wreckage. The bridge had a central span of 90 ft. (with a rise of 9 ft.) and two side spans of 75 ft. (with a rise of 8½ ft.). The springing line at the piers was 5½ ft. above the normal water level; but at the abutments it was at the water level, this arrangement being a feature of the patented design. The thickness of concrete at the crown of the arch was 20 ins. for the middle span and 18 ins. for the side spans. The arches were reinforced by longitudinal and transverse rods, as shown in Fig. 1. Plain round rods were used, and the longitudinal rods were carried down into the piers and abutments, as shown. Vertical rods tie the spandrel walls to the arches. The parapet walls were cast separately in panels and set in place on the spandrels. The width of the roadway was 16 ft. between parapets. The bridge was designed to carry a 20-ton road roller.

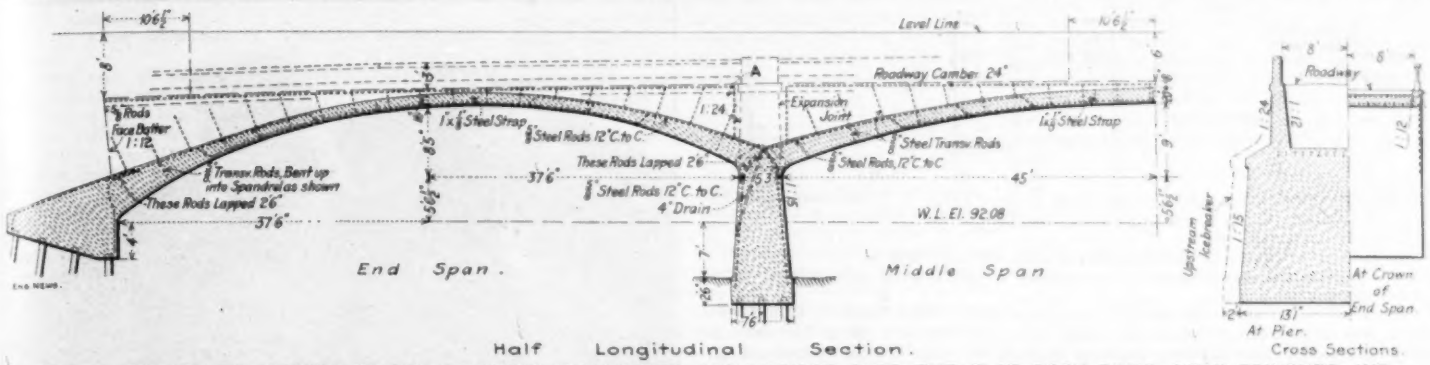


FIG. 1. STRUCTURAL DESIGN OF THE REINFORCED-CONCRETE ARCH BRIDGE OVER THE FLAT ROCK RIVER, NEAR EDINBURG, IND., WHICH COLLAPSED FEB. 28, 1910.

(The foundations were not built as planned [and as shown here]; no piles were used, but the piers were carried about 5 ft. deeper than originally designed.)

The original plans called for pile foundations under the piers and abutments, and this arrangement is show in Figs. 1 and 3. The piers were to be 28 × 7½ ft. on the base, which was to be about 2½ ft. below the bed of the river. Under each pier were to be 26 piles, estimated to carry about 20 tons each. The piles were to be driven to refusal in the usual way. The contract price for the piling was 60 cts. per ft., and it appears that the County Commissioners concluded to save money by omitting the piles altogether. To offset this to some extent they ordered the concrete piers carried to a greater depth than originally provided, or to about 5 or 6 ft. below the bed of the stream.

The concrete mixture was in general 1:3:5, and the fractured portions that are now accessible show a good dense texture, many of the particles of stone and gravel (of small size) having split instead of being torn out. A few of the bars appear to have slipped, and one that is attached to the west abutment but has pulled out of the arch is shown in the photograph, Fig. 6. Others of the longitudinal bars, however, have broken short off, after a considerable re-

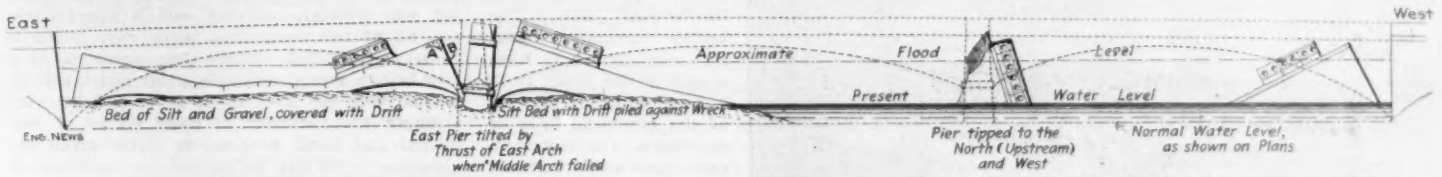

East
West
Approximate Flood Level
Present Water Level
Bed of Silt and Gravel, covered with Drift
Silt Bed with Drift piled against Wreck
East Pier tilted by Thrust of East Arch when Middle Arch failed
Pier tipped to the North (Upstream) and West
Normal Water Level, as shown on Plans
Eng. News

FIG. 2. SKETCH OF CHARACTER OF WRECK, SHOWING ALSO THE GENERAL ELEVATION OF THE BRIDGE AS DESIGNED AND BUILT.

FIG. 3. UP-STREAM SIDE OF THE WRECKED BRIDGE; FROM THE WEST BANK OF THE RIVER.

duction in area at point of fracture. In the east span, the rod which lies vertically and horizontally in the spandrel at (A) in Figs. 1 and 2 has pulled out to a curve instead of a sharp turn, spalling off the concrete at (A). The lower end of the rod protrudes at (B), showing that it has pulled through. As far as can be seen, the arches that have dropped vertically are not badly shattered, and the top surface is broken mainly by transverse cracks at the various changes in angle of the fallen arch. A fine longitudinal crack on the center line appears to be continuous. The coping, of course, is cracked and shattered, exposing some of the top bars in the spandrels.

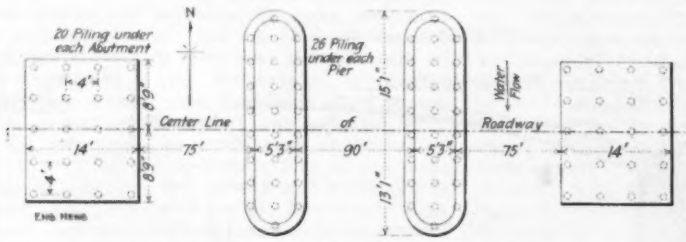


FIG. 4. FOUNDATION PLAN AS DESIGNED.
(This was not followed in construction, all piling being omitted.)

The deeper part of the channel is on the west side, with deep clear water against the abutment, and just above the abutment the silt (still under water) shows evidence of severe scouring. The west pier is in deep water also, but the water appears to be shallower in the middle span. The east span is now over a bed of silt and mud, with pools of still water, and against the wreck of the bridge is piled a mass of drift, composed mainly of brush and corn stalks. The flood is said to have risen to within about 5 ft. of the roadway level, as indicated in Fig. 2. The east half of the bridge has simply dropped vertically, and has not shifted from its original line, so that it was not "swept away," as is sometimes the case with a steel superstructure. The west pier, however, is completely overturned in practically a northwest direction, or in other words it tipped upstream as it fell on its side. The abutments do not appear to have been affected or shifted.

From an examination of the wreck it would appear that the current was concentrated at the west span, and that the scour (perhaps actuated by drift lodged against the pier at the water line) undermined the upstream end and west side of the pier. This caused it to tip forward and endways, breaking away from the two arches which it carried and causing the fall of the two arches. This would leave the east pier without support to counteract the thrust of the east arch, and the thrust would tilt the pier, allowing the arch to drop. As a matter of fact this pier has been tilted very decidedly, as shown in the illustrations, but has not been moved from its original line. The arches springing from this pier appear to have simply swung away from it longitudinally, turning on the springing lines as on hinges. The east span and the east half of the middle span are complete, and have simply dropped vertically as explained above. The west half of the middle span and the entire west span are gone entirely and presumably are broken up and lying in deep water. At the west abutment nothing of the span is above the water except part of the north spandrel wall, but there are great blocks of concrete visible under water. Undoubtedly the twisting or eccentric movement of the pier in tilting upstream would cause a wrecking and distortion of the arches springing from it, while the remainder of the bridge simply dropped when this first movement removed the support and allowed the remaining arch to push the pier forward and fall.

FIG. 6. END VIEW OF THE WRECKED BRIDGE, LOOKING ACROSS FROM THE WEST ABUTMENT.
(At the left is the north spandrel of the arch. In front is the overturned west pier, fallen upstream; the round part at the right is the top of the semicircular downstream end of the pier.)

Fig. 3 is a view taken from a point on the west bank above the bridge and looking across in a downstream direction. Fig. 6 is a view taken from the middle of the west abutment and looking directly along the line of the bridge. The projecting rod in front is one that has h[illegible] to the abutment but pulled out of the arch. [illegible]s smooth and black and apparently had not [illegible]een well bonded in the concrete. At the left [illegible] the north spandrel wall and parapet of the [illegible]len arch. Directly in front of the abutment is the overturned pier, the round part on its left being the top of the semicircular end of the downstream face of the pier.

FIG. 5. NORTH SIDE OF MOST EASTERLY PIER, FLAT ROCK RIVER BRIDGE.

In regard to the neglect of the engineer's provision for foundations, the accident may be compared to that of the Peoria reinforced-concrete arch bridge, described in our issue of May 13, 1909, p. 529. At Peoria, foundation piles were used, and in view of the liability of scouring by floods the engineers provided for sheet piling to enclose the foundations. This sheeting was omitted, however, and it appears that not all of the foundation piers were driven to rock, as specified. These two accidents to a city bridge over the Illinois River and a country bridge over the Flat Rock River indicate very strongly the necessity of some system of municipal and local government under which engineering work can be carried out according to the plans of competent designers and under proper supervision, and will not be liable to changes ordered by or neglect permitted by incompetent authority, however well-meaning that authority may be.

Notes from Engineering Schools.

NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS.—Plans have been approved for a new engineering building, at West Raleigh, to cost $50,000. This building will be 170 ft. long by 90 ft. deep, three stories in height.

UNIVERSITY OF ILLINOIS.—A Bureau of Municipal Research is proposed, to render to municipalities information regarding practice in various matters of municipal government. This is explained by the following circular letter which has been sent out by Mr. J. W. Garner, Professor of Political Science:

The University of Illinois is considering the establishment of an extension division to be known as a bureau of municipal research, the purpose of which is to collect and make available for the use of the towns and cities of the state the latest information regarding the principal problems of municipal government in Illinois.

If, for example, any town or city desires information concerning the best methods of garbage disposal, the paving of streets, special assessments for public improvements, sources of municipal revenue, etc., we want to be able to furnish the officials of such town or city full information regarding the manner in which other cities are solving the problems and how their methods have worked out in practice.

In short it is our purpose to establish here at the state university a central clearing house of municipal experience and information, the benefits of which shall be available without cost to any city or town in the state.

UNIVERSITY OF CALIFORNIA.—The Graduate School has announced the following scholarships and fellowships for 1910-11, of interest to members of the engineering professions:

(1) OPEN TO GRADUATES EITHER OF THE UNIVERSITY OF CALIFORNIA OR OF OTHER COLLEGES OR UNIVERSITIES:

Ten University fellowships, yielding $400 each, and available in any of the colleges of Letters, Sciences, and Engineering.

Two Flood fellowships in Economics, yielding $400 each.

Two John W. McKay, Jr., fellowships in Electrical Engineering, yielding $600 each.

One or more Lick Observatory fellowships in Astronomy, yielding $600 each.

One or two fellowships in Physics under the Whiting fund, yielding $600 each. (Applications for these fellowships will not be received until 1911, for the year 1911-12.)

One James M. Goewey scholarship in Natural Science, yielding $250.

(2) OPEN TO GRADUATES OF THE UNIVERSITY OF CALIFORNIA ONLY:

One or more LeConte Memorial fellowships, yielding $600 each and available in any department.

The Whiting fellowship and the LeConte Memorial fellowships may be given either to graduate students at the University of California or to graduates of the University of California appointed to study elsewhere, as the Graduate Council may determine. The other fellowships and scholarships are to be given to graduate students in residence at the University of California. Candidacy for fellowships is, in general, restricted to students who have completed at least one year of graduate work, and who intend to proceed to the degree of Doctor of Philosophy, or its equivalent. Candidacy for scholarships is open to students who have received the Bachelor's degree, or who expect to receive it at the close of the current-half year. Tuition charges in the University are limited to $10 per half-year for non-residents of California. Applications should be filed with the Recorder of the Faculties by March 30.

AN EXPLOSION OF DYNAMITE March 12 at Tunstall Bay, Bowen Island, B. C., killed five men. They were packing the dynamite into boxes.

A COAL MINE EXPLOSION at South Wilkes-Barre, Pa., March 12, killed seven men in the No. 5 colliery of the Lehigh & Wilkes-Barre Coal Co.

TWO EXPLOSIONS IN A COAL MINE near Athens, Ohio, March 11, started a fire which made it necessary to seal up the mine, throwing 400 men out of work. No one was injured. The mine is known as Sunday Creek mine No. 209.

A FREIGHT LOCOMOTIVE BOILER EXPLODED March 8 on the St. Louis & San Francisco R. R., near Hoxie, Ark. The engine was running at the rate of 30 mi. per hr. The engineer, fireman and brakeman were killed.

A CONFLAGRATION AT JAMESTOWN, N. Y., March 12-14, destroyed a factory building, three of the principal business blocks and a hotel. The fire started at night on March 12 in the Gokey factory building and it was thought that the flames had been extinguished, but at 2 a. m., March 14, they broke out anew and were soon beyond control of the local fire department. Before assistance could be sent from Buffalo the Gokey business block, the Erie Hall block, the J. F. Briggs block and the new Sherman hotel had been consumed.

A CONCRETE FLOOR PANEL COLLAPSED at Winnipeg, Man., in the new Union Station just being built (see Eng. News, June 18, 1908, p. 663). The concreting of floor and roof slab was done last fall, but one panel in the roof, left unfilled at the time, was concreted only in December and had since been supported by shores. It collapsed on March 12, apparently a short time after the shores were taken out. One man was killed and several others badly injured. The panel which failed was about 10 x 12 ft., and the slab was 5 ins. thick.

A 3-CENT-FARE RAILWAY across Manhattan Bridge and extending to the North River in the Borough of Manhattan and to the center of the business district of Brooklyn has been approved by a committee of the New York Board of Estimate and Apportionment. The proposed railway will be known as the "Manhattan Bridge 3-Cent Fare Line." The proposal of the company for building this railway differs from all others thus far made for a railway across Manhattan Bridge, in that the proposed railway extends beyond the bridge instead of dumping passengers at either end and necessitating their paying an additional fare to go to their objective points. The action of the above-named committee is only preliminary to the necessary grant of authority. The next step is the preparation of plans by the Chief Engineer of the Board of Estimate, after which presumably the franchise for the line will pursue its usual course before the city authorities.

A LARGE SHORTAGE OF FREIGHT CARS is expected by railway officers during the coming season. The surplus of idle cars which persisted from November, 1907, till September, 1909, is now only a memory. The surplus cars reported on some roads since September have been offset by the car shortage reported on other roads. With this condition existing in early spring, it is probable that every available car and all the new cars now in the shops will be demanded for service by the coming fall.

A VALUATION OF THE WORKS OF THE PEORIA Water Co., Peoria, Ill., is being made for the city of Peoria by Mr. Benezette Williams, of Chicago. It appears that in June, 1908, the City Council of Peoria, without any previous investigation of the subject, passed an ordinance making a flat reduction of 33⅓% of the water rates charged by the above-named company. An injunction against the enforcement of the ordinance was obtained by the company and the ordinance was subsequently repealed. The city declined a proposition on the part of the company, made at the time of the introduction of the ordinance, to submit the matter of rates to arbitration. Later on, the company, upon request, submitted to the city a statement of its receipts and expenditures for 1908, and also placed a valuation upon its plant. The city was given permission by the company to have these figures checked by expert accountants, which was subsequently done. Still later, Mr. Williams was employed by the city to make a valuation of the property of the company and is now engaged on that task.

THE SAN PEDRO, LOS ANGELES & SALT LAKE Railroad, which was so severely damaged by floods about the 1st of January, is being rapidly reconstructed. For a distance of about 80 miles the roadbed was more or less washed out, and in some cases was entirely destroyed. Temporary repairs and reconstruction are being rushed with all possible dispatch, and it is hoped to have trains running over the line again within the next 60 to 90 days. In addition, several surveying parties are now engaged on the location of a new high line through the district affected by floods, which will be placed at an elevation sufficiently great that there will be no danger of traffic interruption from flood in the future.

OIL-BURNING LOCOMOTIVES must be used by the railways in the Adirondack forest preserve during the dry months of summer. The New York Central R. R. Co. recently applied to the Public Service Commission for one year's extension of the time in which oil-burning locomotives must be installed. The Commission, however, has denied the application.

PANAMA CANAL EXCAVATION during February equalled 2,602,995 cu. yds., a daily average of 113,174 cu. yds. for the 23 working days. The rainfall for the month was 2.11 ins. It is interesting to note the uniformity with which this excavation is carried on when rainfall and other climatic conditions are the same. Thus, the daily record for January of this year, with a rainfall of 2.12 ins. was 113,277 cu. yds.

During February the amount of concrete laid was 75,602 cu. yds. and 576,951 cu. yds. of fill were placed.

HYDROGRAPHIC SECTION OF THE BRUSSELS INTERNATIONAL EXPOSITION.—The International Exposition to be held at Brussels, Belgium, from August to October, 1910, has in its scientific division a group assigned to the science and practice of hydrography and hydrology. This section covers all those sciences which take up the study of water resources, of modern methods of water purification and the method of analysis of waters for drinking and for mechanical purposes. The committee of this section has for its president M. Leon Gerard, and for secretary M. Ernest van den Broeck. The committee has already commenced to lay out its exhibit space, and is particularly desirous of having all those who care to exhibit there write to it as soon as possible. The spaces are free to the exhibitor, but are reserved for exclusively scientific developments, and not for advertising. All requests for information should be addressed to Secretariat de la Section d'Hydrologie Scientifique, 39 Place de l'Industrie, Brussels, Belgium.

A BRIDGE-BUILDING FRAUD in Indiana recently resulted in the conviction of the general manager of a bridge company for presenting a fraudulent claim against the county. The contracting bridge company had built the bridge of lighter steel than called for by the contract plans, and thereby "saved" some 35% of the total weight of the structure. It also made the connections with bolts instead of the specified rivets. There does not appear to have been any inspection or control by the County Engineer. A competing bidder, who had been underbid, although claiming in this instance to have put in a bid at cost, was the chief prosecuting witness; he discovered the steal while inspecting the material and structure to learn how the other man could make the lower bid.

A 1,200-VOLT DIRECT-CURRENT RAILWAY system, it is reported, will supplant the 3,300-volt, single-phase system on the 50-mile interurban line between Milwaukee and Watertown, Wis. The reasons for the change are not stated. The new cars will be equipped with two 600-volt motors, operated in series normally on the country stretches of 1,200-volt line, but changed over to a parallel connection for 600-volt lines in towns. Two substations will be used so that the radius of maximum direct-current transmission will be about 10 miles.

A MERCURY-VAPOR LIGHTNING ARRESTER has been patented by Mr. Percy H. Thomas, M. Am. Inst. E. E., of New York City. Simple mercury-vapor vacuum tubes, much like the tubes of mercury-arc lamps, rectifiers, etc., are placed in series with a spark gap between the ground and the line to be protected. The tubes are successively shunted by condensers. When the line potentials rise sufficiently to break down the ordinarily high resistance of the tubes, a path is opened up for the discharge to ground. After the discharge has been passed, the high resistance, to the flow of alternating current, is restored, preventing heavy line currents to the ground.

DRY ELECTRO-PLATING.—Mr. August Rosenberg in a paper presented before the Society of Arts of Sheffield, England, described a method of dry electro-plating one metal with another. The metal to be deposited is mixed in powdered form with some electro-positive metal and with chalk, clay or inert substances to lessen rapidity of reaction, to prevent unequal color and to polish the deposited film. Mr. Rosenberg calls his process the "Galvanit." The application is simple and no preliminary chemical treatment is needed provided the articles to be plated are fairly clean and bright. The powder is to be rubbed, moistened with a brush or rag on the metal. Although the application of heat is reported not to be necessary, yet usually a thicker deposit can be secured and in a shorter time than otherwise. Even nickel can be deposited in this way, according to Prof. S. P. Thompson, who stated at this meeting that he had been converted from skepticism.

A STORAGE BATTERY STREET CAR equipped with the new type of Edison nickel-iron cells, described in Engineering News, Feb. 3, 1910, p. 125, has been placed in experimental operation over the cross-town lines on 28th and 29th Sts., New York City. Tests made on March 1 have given the following data:

Length of car	26 ft.
Gross weight of car	6 tons.
Distance covered	52.47 miles.
Total KW.-hrs	35.93
KW.-hrs. per car mile	0.685
KW.-hrs. per ton mile	0.114

This line has few grades but several sharp curves. The weather during the test was rainy. The figures shown above do not show the efficiency of charging and discharging the battery and are presumably readings of energy drawn from the storage battery.

STEEL PASSENGER CARS are being built and used in rapidly increasing numbers by the Pennsylvania R. R. This line has over 300 such cars already in service, and as many more under construction. Coaches, mail, baggage, combination and dining cars are included in these. Pullman cars of steel are also to be put in service soon, the Pullman Company having been at work for several years getting up designs for sleeping cars of all-steel construction. It is expected that by the end of 1910 the Pennsylvania will have about 900 steel cars of its own and 500 steel Pullmans in service.

THE GATUN LOCK WALLS at Panama are to have large rocks imbedded in the concrete. Large stones from the quarries at Porto Bello will be brought to Gatun and handled in skips from the barges to the lock pits. It is expected to use large rock to the extent of about 10% of the total volume of concrete, according to the "Canal Record" of Feb. 23.

A TOTAL OF 3,482,186 TREES have been planted by the Pennsylvania Railroad Co. since it began forestry operations in 1902. The plantings of the company have ranged from 13,610, in 1902, to 1,054,010, in 1909. We reprint, from a statement issued by that railroad, the following information regarding this forestry work:

Prior to last year, the Pennsylvania's forestry operations were confined to a limited area between Philadelphia and Altoona. In 1909, however, 7,800 trees were planted near Pomeroy, Pa., 188,200 in the vicinity of Vandyke, Pa., 35,000 near New Brunswick, N. J., 352,000 near Eyer, Pa., 30,000 on the right-of-way near Me-

tuchen, N. J., 161,825 at Denholm, Pa., 204,500 at Conewago, Pa., and 74,500 at Parkton, Md.

The total number of plants shipped from the company's forest nursery at Morrisville, Pa., was 1,240,381. There are at the present time in the nursery, trees for forest planting ranging in age from eight months to six years. During the year five bushels of acorns were planted in their permanent places as an experiment.

A special effort was directed last year to growing ornamental shrubbery for use in parking the lawns around stations and unoccupied places along the roadway. To save the time required to grow these from seed, 6,000 plants were imported from France. They were placed in beds at the company's nursery at Morrisville. Part of them will be ready for transplanting this year, and the remainder in 1911. There are some 56,000 trees and shrubs which are now being held in nursery rows until they become large enough for ornamental trees.

Under the direction of the Forester, a large pressure treating plant has been in operation at Mt. Union, Pa., since July 1, 1909, and a small experimental non-pressure plant has been installed at Greenwich Point, Philadelphia. A second pressure plant is now under construction at Greenwich Point, and with all three in operation the total output will be about a million and a half ties per annum. There have been creosoted up to Dec. 31, 1909, at Mt. Union, 135,727 No. 1 and 46,625 No. 2 ties, 80,000 ft. B. M. of bridge timbers, 25,000 lin. ft. of trunking and capping for signal wires, and 25,000 wood paving blocks. Reducing all of this material to board feet gives a grand total of 7,861,000 ft. of timber treated at Mt. Union. The non-pressure plant at Greenwich Point has turned out ties and timber equivalent to 432,000 ft., also 5,000 fence posts and 25,000 paving blocks.

This forestry work has been carried on under the direction of Mr. E. A. Sterling, Chief Forester. Articles on certain phases of the work appeared in Engineering News of Aug. 29, 1907, and May 14, 1908.

THE BRITISH EMPLOYERS' LIABILITY LAW is to be applied by the Chicago, Milwaukee & St. Paul Ry. Co., in compensating the widows and other dependents of the Cherry Mine disaster victims. Under this plan the widows will receive three times the annual earnings which their husbands were receiving at the time of death, and the question of the company's legal responsibility for the disaster will be waived.

THE U. S. GEOLOGICAL SURVEY AND THE CENsus Bureau have entered into a joint arrangement by which the Survey is relieved of the collection of statistics of the annual production of minerals for the year 1909. That work is, by this agreement, merged in the Census Bureau's activities under the Thirteenth Census act, which requires a census of mines and quarries for 1909. Consequently, the Survey will not this year send its own schedules directly to the mine and quarry operators. The Census Bureau's general and supplementary schedules relative to this branch of its decennial work include the inquiries in which the Survey is interested and such other data as may be necessary for the latter's reports will be furnished the Survey by the Census Bureau. The schedules will be collected by the Census special agents and enumerators. This cooperative arrangement was in recognition of the necessity of uniformity in the compilation of the statistics, the elimination of duplicate work and inquiries and the desirability of economy in the collection of the required data.

INDIA RUBBER INSULATION.—Mr. I. W. Henry in the "India Rubber World," Jan. 1, states that while, 20 years ago, there were only five concerns making rubber-insulated wires in this country with an aggregate annual output valued at $3,000,000, there are now over 20 makers with an aggregate output of $25,000,000. At first the American makers used the English method of pressing two strips of rubber together about the wire and rolling, but later a method, used with gutta percha in England, was employed generally. In this the rubber is forced in a compact seamless mass around the conductor passing through the same die from which the rubber is extruded. This was found satisfactory for submarine-cable cores as well as for lighting wires.

Personals.

Mr. C. L. de Muralt, M. Am. Inst. E. E., has been appointed Professor of electrical engineering at the University of Michigan. In 1907-09 he acted as a non-resident lecturer in the same school, while maintaining his office in New York City.

Mr. C. A. Greenidge, M. Am. Inst. E. E., General Manager of the electrical department of the Utica Gas & Electric Co. for the past five years, has been appointed Engineer in the operating department of J. G. White & Co., of New York City.

Mr. F. H. Nickle has resigned his position as Engineer for the Pennsylvania Salt Manufacturing Co., at Wyandotte, Mich., and is now associated with the firm of McDonald & Nickle, engineers, of Detroit, Mich. He will engage in vacuum evaporating work and salt plant engineering.

Mr. Wm. W. Randolph, formerly Vice-President of the firm of Humphrey & Glasgow, of New York and London, with which he had been associated since 1894, in the design, construction and operation of gas works, coke-oven plants, etc., has opened an office as a consulting engineer at 165 Broadway, New York City.

Mr. K. P. Swensen, heretofore Assistant Engineer with C. A. P. Turner, consulting engineer, of Minneapolis, Minn., has been appointed to a position in the department of science of the University of Nanking, Nanking, China. The university is organizing a school of mines. Mr. Swensen expects to remain in Nanking at least one year.

Mr. H. C. Kittredge, Assoc. M. Am. Soc. C. E., formerly with the American Pipe & Construction Co., of Philadelphia, Pa., and with the firm of Knight & Hopkins, of Rome, N. Y., has opened offices at 42 Werner Park, Rochester, N. Y., as a designing and consulting engineer on the construction of plain and reinforced-concrete structures.

Mr. W. L. Park, General Superintendent of the Union Pacific Ry. at Omaha, Neb., has been appointed Vice-President of the Illinois Central R. R., in charge of operation, succeeding Mr. I. G. Rawn, who resigned some time ago to become President of the Chicago, Indianapolis & Louisville Ry. Mr. Charles Ware, Superintendent of the Nebraska division of the Union Pacific, has been appointed to succeed Mr. Park as General Superintendent.

Obituary.

John L. Arts, General Manager of the Burden Iron Co., of Troy, N. Y., died at that place March 14. He had been connected with the Burden firm for 30 years.

Harry W. Jayne, member of the American Institute of Chemical Engineers, died March 7 at his residence near Philadelphia, Pa., aged 52 years. Mr. Jayne was a graduate of the University of Pennsylvania and later received the degree of Ph. D. from the University of Strasburg. He was well known among chemists as an expert on coal tar products.

Thomas McK. Laughlin, Secretary and Treasurer of the Jones & Laughlin Co., steel manufacturers, of Pittsburg, Pa., died March 11 at his home in that city. Mr. Laughlin was born in 1875 and was a graduate of Yale University in the class of 1897. He became a brother-in-law of President William H. Taft in 1902 when he married Mrs. Taft's sister, Miss Herron, in Cincinnati, Ohio.

L. W. Brown, Civil Engineer in charge of the Southern Pacific Co.'s oil properties in California, died March 7, at Los Angeles, Cal. Mr. Brown was for a number of years Division Engineer of the Southern Pacific Ry. at New Orleans, La., and during this period he acted as consulting engineer in connection with a number of municipal projects in that city. Mr. Brown was the inventor of an improved process of refining asphaltum oils.

Benjamin E. Noyes, driver of some of the earliest locomotives on the Baltimore & Ohio R. R., died March 13 at Baltimore, Md., aged 91 years. Mr. Noyes entered the service of the Baltimore & Ohio when 20 years old. In 1851 he went to Russia to participate in the construction of the railway from Moscow to St. Petersburg. He remained in Russia for some time afterward as superintendent of shops, returning to Baltimore in 1865.

Engineering Societies.

COMING MEETINGS.

AMERICAN WATER WORKS ASSOCIATION.
April 26-30. Annual convention at New Orleans, La. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 5-7. Annual meeting at Pittsburg, Pa. Secy., Jos. W. Richards, South Bethlehem, Pa.

APPALACHIAN ENGINEERING ASSOCIATION.
May 6-7. Annual meeting at Winston-Salem, N. C. Secy., Henry M. Payne, Morgantown, W. Va.

AIR BRAKE ASSOCIATION.
May 10. Annual meeting at Indianapolis, Ind. Secy., F. M. Nellis, 53 State St., Boston, Mass.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 17-19. Annual meeting at Chicago, Ill. Secy., Franklin H. Wentworth, 87 Milk St., Boston, Mass.

AMERICAN RAILWAY ASSOCIATION.
May 18. Annual meeting at New York City. Secy., W. F. Allen, 24 Park Pl., New York City.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
May 19-20. Semi-annual meeting at Cincinnati, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

CENTRAL RAILWAY CLUB.—At the meeting in Buffalo, N. Y., March 11, a paper on "Electric Car Lighting" was presented by Mr. J. R. Sloan, of Altoona, Pa.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.—It is announced that President Taft will be present at the banquet following the annual meeting on March 17, and will deliver an address.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—A meeting of the mechanical section was held at Montreal, Que., March 10 at which Mr. Wm. C. Brown, of the McDougall Caledonia Iron Works Co., gave an illustrated address on novel municipal turbine pump installations.

At the general section meeting in Montreal, March 17 two papers are to be presented as follows: "Sub-aqueous Concrete Work," H. R. Lordly; "Grade Separation," W. H. Breithaupt.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The date of the meeting at Charlotte, N. C. has been changed from March 23-25, as originally announced, to March 30-April 1. Papers added to the program since its publication in our issue of Jan. 20 are as follows: "Modifications of Hering's Laws of Electrodes for Electric Furnaces," A. E. Kennelly; "The Proportioning of Furnace Electrodes," Carl Hering; "Some Demonstrations of Lightning Phenomena," E. F. F. Creighton, illustrated by experiments. The paper by Mr. Charles H. Baker named in our issue of Jan. 20 does not appear on the later edition of the program.

ENGINEERS' CLUB OF ST. LOUIS.—At a meeting on Feb. 18 resolutions were adopted by the Club urging the creation by Congress of a department or bureau of public works to include the Coast & Geodetic Survey, the Geological Survey, the Reclamation Service, the work of River and Harbor Improvement and other bureaus conducting engineering work. In case such a bill is not passed, the resolutions urged upon Congress the modification of the pending bill (H. R. 7117) to increase the corps of engineers so that civilian engineers may be entitled to the same pay, rank and tenure of office as engineer officers. The resolutions were drafted by a committee of the Club, of which Mr. Edward Flad was chairman. Copies of the resolutions can be obtained from the Secretary of the Club, Mr. A. S. Langsdorf, Librarian of Washington University, St. Louis.

AMERICAN INSTITUTE OF MINING ENGINEERS.—At the annual meeting in Pittsburg, Pa., March 1-4, some of the papers presented in oral abstract by their authors were as follows: "Systematic Exploitation in the Pittsburg Coal Seam," F. Z. Schillenberg and Edward McGrew, Pittsburg, Pa.; "A Commercial Fuel-Briquetting Plant," William H. Blauvelt, Syracuse, N. Y.; "Dust Explosions in Coal Mines," George Samuel Rice, Pittsburg, Pa.; "The Gaseous Decomposition Products of Black Powder," C. M. Young, Lawrence, Kan.; "Work of the Technologic Branch of the U. S. Geological Survey at Pittsburg, Pa.," Dr. Joseph A. Holmes, Washington, D. C.; "The Action of Explosives in Rocks of Different Degrees of Hardness," W. O. Snelling, Pittsburg, Pa.; "History of the Introduction of Basic Steel in the United States," George W. Maynard, New York; "Electric Mine Hoists," Karl A. Panly, Schenectady, N. Y.; "Field Investigations of Structural Materials for Use in Federal Buildings," E. F. Burchard, Washington, D. C.; "Coal and Iron Ore in Western Oaxaca, Mexico," J. L. W. Birkinbine, Mexico, D. F. In addition to these there was a long list of papers read by title only for subsequent publication in the "Bulletin."

A visit to the testing station of the U. S. Geological Survey was made on the afternoon of March 2, and on the following day electric and blast furnaces of the Carnegie Steel Co. and the plant of the Mesta Machine Co. were visited.

NEW ENGLAND WATER WORKS ASSOCIATION.—The regular monthly meeting of the Association was held in Boston on March 9. A discussion on cleaning of water mains was proposed, but as no one seemed ready to take up the subject on the spur of the moment it was postponed until a later meeting. A number of members took part in the discussion of the vibration of water hammers in pipes leading from a power-driven geared pump. The consensus of opinion was that the difficulty was caused by an insufficient air chamber. Several members reported similar trouble, and stated that in placing gage glasses on their air chambers they found that the chambers contained no air and that by adding an air pump or an air compressor to force air into the chamber the trouble had been overcome.

An interesting talk upon medieval towns of Germany, illustrated by many handsome lantern-slides, was given by Mr. Desmond FitzGerald, M. Am. Soc. C. E. The lantern-slides are made from photographs taken by Mr. FitzGerald during a vacation trip.

A short paper entitled "Double Filtration of Polluted Water" was read by Mr. Harry W. Clark, Chemist of the Massachusetts State Board of Health. The Massachusetts State Board of Health has carried on experiments on double filtration since 1893. Double filtration has been many times proposed for highly polluted water and also for overcoming large growths of algae and similar microscopic organisms. Experiments have been carried on by filtering the Lawrence city water, which has already passed through the city filter; also by double filtration of the Merrimac River water, and of other water much more highly polluted than that. The average results were shown by tables projected upon the screen and indicated that double filtration has no advantage either in bacterial efficiency or in economy in cost of scraping and caring for filters, over single filtration at a reasonable rate, in the case of these waters.